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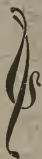
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A Study of Handedness

By

W. FRANKLIN JONES, Ph. D.

Head of Department of Education
and Director of Graduate Courses
University of South Dakota



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EQUIPMENT FOR DETERMINING HANDEDNESS.

In order to respond to the demands of school officials, physicians and others interested in the scientific determination of handedness, the following equipment is available to supply the psychomotor

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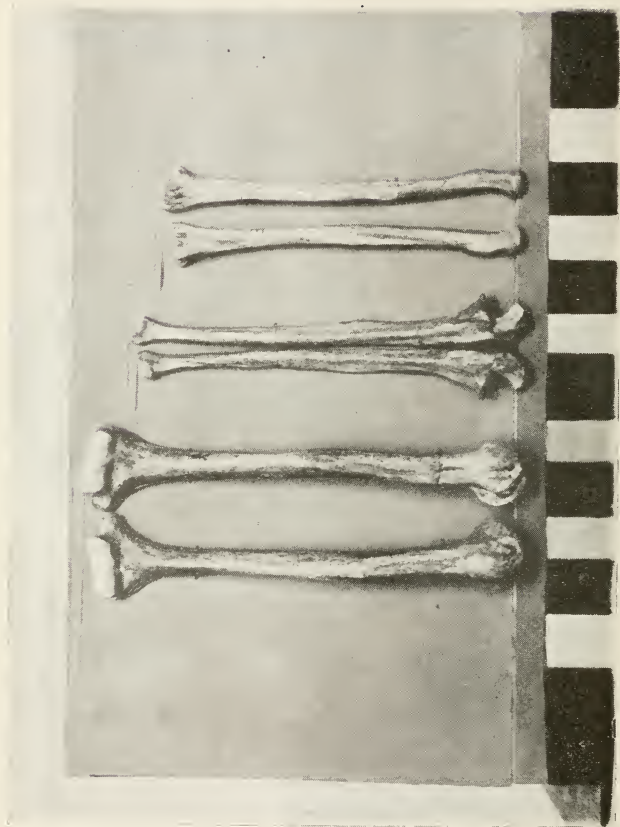


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ULNAE

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THREE PAIRS OF BONES FROM THE HUMAN ARM
(Showing bones of right arm longer)

A STUDY OF HANDEDNESS.

The left handed child has been an educational bone of contention. Tradition has decreed that left handedness is only individual habit, and so its followers have set to work industriously to transform all left handers into right handers. Many cases of left handedness have apparently disappeared under this treatment, and thus on the surface, at least, tradition has been justified. Only here and there has been found a child so stubbornly left handed that no training, however persistent, has been quite able to transfer him to the right hand and arm; and it is this little group of survivors that has set many an investigator to work on the problem of handedness.

On the other hand, there have been those who, after more or less careful study, have maintained that left handedness is a born trait, and that no parent or teacher should assume to interfere with nature's process. They have pointed out that the majority of the human race is undoubtedly right handed born, but that there is a respectable minority that is left handed born; yet the evidence on which these claims have been based has been without scientific proof, and the proportion of born right and and born left handed individuals has not been established, indeed can not be established until some reliable means have been devised for distinguishing born handedness from acquired handedness. Gould, Cunningham, Jackson and others have made many shrewd observations that give some ground for their claims, and Biervliet and Baldwin are to be given credit for having given us the first scientific data; but we need further evidence if the foregoing controversies are to be settled.

Finally, we find a third class of students who reason from bilateral symmetry to ambidexterity. "Two equal arms" is their creed, and it has filled England with ambidexterity societies. These societies seem to feel called upon to rescue the race from "one sided development." That their studies and their teachings have been both industrious and heroic is shown by the fact that their opponents have called them "ambidexterity cranks." They, too, have given us little evidence.

It is clear that opinion will never settle these, any more than it has settled other, controversies; and we shall continue variously to treat and perhaps to mistreat the left handed child, both in home and in school, until we know him better.

Then, too, if we err because we do not understand left handedness, shall we say we are certain of our dealings with right handedness? If a child is born with a major and a minor arm, may he not more or less hopelessly injure the major arm and so be forced to adopt the minor arm? May an injury to the major arm early in life shift the child over to the minor arm, unknown to parents, and thus send the child through life mistaken as to his own birthright of hands and arms? If it is really possible to transfer from one arm to the other by accident, then how is any one to know whether he is actually born right or left? If we could but discover some scientific means, some measures or scales, for determining both born handedness and adopted handedness, then we could answer these questions.

Other questions arise. If an individual is transferred from the major to the minor arm, either by accident or by purposive interference, what are the consequences? Are the possibilities of the minor arm minor possibilities as compared with those of the major arm? Does hand transfer mean ultimate loss of hand skill? and does this interference, whether accidental or purposive, bring physiological disaster? If, again, we had reliable means of determining both born handedness and adopted handedness, we could apply tests of hand skill to right handers, left handers, and transfers, and thus discover by experiment the consequence of transfer in terms of hand and arm skill; and this in turn might pave the way to a study of physiological consequences attending hand-transfer.

It was in the hope of discovering some means, some measures, or scales, that could make it possible to proceed with a scientific handling of the problems of handedness that this investigation was started and carried on for ten years. Re-stated for the sake of clearness, this investigation deals with the following multiple problem.

THE PROBLEM STATED.

Part I. (1) HOW CAN WE DETERMINE, *de novo*, WHETHER A CHILD IS BORN RIGHT OR LEFT HANDED? (2) HOW CAN WE DISTINGUISH BORN HANDEDNESS FROM ACQUIRED HANDEDNESS?

Part II. SHOULD THE LEFT HANDED CHILD BE TRANSFERRED TO THE RIGHT HAND?

MATERIAL AND HANDLING.

The material used in this investigation consists of the following measures taken of each arm of twenty thousand individuals ranging in ages from stillborn to centenarian:

1. Length of the ulna-plus (the ulna plus the hand to the middle knuckle of the little finger).
2. Circumference of the palm.
3. Circumference of the wrist.
4. Length of the humerus.
5. Circumference of the forearm relaxed.
6. Circumference of the forearm contracted.
7. Circumference of the arm relaxed.
8. Circumference of the arm contracted.

Additional material was derived by taking measures of the bones of the arms of a dozen cadavers, and of a dozen unpieced human skeletons.

The Brachiometer.

To facilitate the work, a simple instrument (called "brachiometer") was devised to give exact and corresponding measures of the two arms. It is shown in the cut that follows. It is made of hard wood, with working parts of brass. The base of the instrument is $2\frac{1}{4}$ by 6 inches; and the upright, bearing the measuring scale, the sliding indicator, and the metallic arm cuff, is 18 inches in length. The arm cuff is a brass band, in two parts, each part secured to the upright and hinged so as to make it adjustable to arms of varying sizes.

The Measuring Details.

1. Ulna-plus.—In taking the ulna-plus the brachiometer was usually placed on a low table at which the subject was seated. (The measures may be taken with the subject standing; but if a table is used it must be low enough to give an acute angle at the elbow.) The bared arm was placed with the point of the elbow pressing firmly downward on the base of the brachiometer and the arm extending along the



MEASURING THE ULNA-PLUS

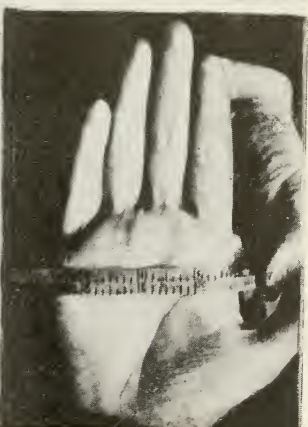
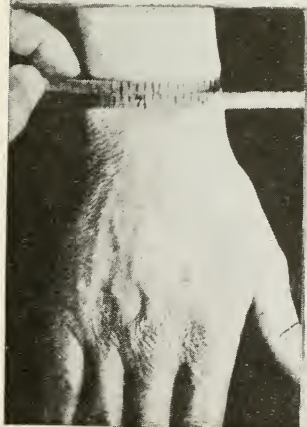
upright measuring scale. The forearm, hand, and lower joint of the little finger were carefully held in a straight line, with the little finger bent at right angle at the middle knuckle. (Practice in placing and straightening the arm is required to give reliable measures.) The length of the ulna-plus was then found by sliding the indicator down the scale until it rested on the exposed middle knuckle of the little finger, the reading being taken on the scale just under the indicator. (The length of the ulna-plus is taken, rather than the length of the ulna, for the reason that the former is far more readily derived, as may be seen by trial.)

2. *Circumferences of Forearm.*—Without removing the arm from the brachimeter, the halves of the metal cuff were pressed against the forearm and a pencil line drawn on each side of the bare forearm along the lower edge (along the upper edge with a long arm) of the metal cuff. The brachimeter was then removed, and with the arm held in the same position as when marked, the circumference of the "forearm relaxed" was found by measuring to the pencil lines with a narrow and flexible tape (anthropometric tape) snugly drawn. (Practice is required to enable the operator to draw the tape at constant tension.) Then, without removing the tape, a pencil was slipped into the hand of the arm being measured and the subject was instructed to grip the pencil three times with increasing strength, making the third the maximum grip. During the third grip the measure was taken for the "forearm contracted." (The metal cuff locates approximately the zone of maximum swell of the forearm.)

3. *Circumference of Palm.*—The palm was fully opened and the fingers held in contact. The tape was snugly drawn around the palm just below (on thumb side) the points where the palm-creases disappear on the edges of the palm.

4. *Circumference of Wrist.*—The wrist circumference was taken over the extreme bony knobs, with arm muscles relaxed.

5. *Length of Humerus.*—In taking the length of the humerus the subject was instructed to place his hand on his hip; then the elbow was forced around to the back as far



MEASURING THE MUSCLE SWELL OF THE
ARM _____ FOREARM
MEASURING THE CIRCUMFERENCE OF THE
WRIST _____ PALM

as possible in order to throw the shoulder end of the humerus out in position to favor the measuring. (The less clothing on the shoulder and arm the better, and no heavy clothing was allowed to cover the shoulder during the measuring.) The brachiometer was then placed with its base pressing firmly against the elbow and the upright scale extending along the outside of the arm to the shoulder. The indicator was pressed snugly against the head of the humerus as shown by its bulge in front of the shoulder during the backward movement of the elbow, and the brachiometer reading was taken for the "length of the humerus."

6. Circumference of Arm.—In taking the circumferences of the arm the subject was first instructed to fold the arm upon itself firmly by bending it at the elbow, so as to reveal the zone of maximum swell of the biceps. This zone was pencil marked at its center, and the distance of the mark from the elbow was carefully measured by the brachiometer. Another pencil mark was made on the opposite side of the same arm and at the same distance from the elbow as shown by the brachiometer. Similar points were marked on the other arm, using the same distance from the elbow for the two arms. (The point of maximum swell of the biceps is midway of the humerus; and since the point of maximum swell is not a mere point but a zone from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch in width in different arms, no allowance need ordinarily be made for the difference in lengths of the two arms of the subject.) The brachiometer was then laid aside and the subject instructed to extend the arm outward in a straight line. The tape was snugly adjusted about the arm as indicated by the pencil marks, and the reading was taken for the "arm relaxed." Without change in the position of the tape, the subject was instructed to fold the arm firmly upon itself again and then shake the clenched fist in a brief but violent quiver. The back and forth range of the quiver was limited to about a fourth of an inch, and a little warming up practice was always given. Three brief efforts of increasing strength were made in each case, and during the third and maximum effort the measure was taken for the "arm contracted."



MEASURING THE HUMERUS

DATA.

In the following tabula are given the measures of approximately 300 pairs of arms, selected from the total 20,000 as follows: The first list of 200 serial measures is a random selection, giving a working idea of the general run of arm measures in living beings. The next list is a random selection of 40 serial measures from the group of living left handers, showing the general run of measures of left handed individuals. The third list is a random selection of 60 serial measures from the group of living transfers, showing the general run of measures of individuals who have been transferred by one or more of various causes stated or suggested in so far as known. The fourth list gives the arm measures of a half dozen cadavers and of a dozen *unpieced human skeletons. The cadaver measures show the differences in the bone equipment of the two arms as those differences appear when the bones are freshly removed from the human body. The skeleton measures show the differences as revealed by the bones when removed and thoroughly dried. (The skeletons used are a collection of Arikara Indian skeletons unearthed and prepared by Curator W. H. Over, of the Department of Geology of the University of South Dakota. They are now on exhibition in the University Museum.)

The data are tabulated in fifteen columns. In the first column is given the number of the individual as listed; in the second is given the sex, "M" indicating male and "F" female; and in the third column is given the approximate age. Exact ages are not needed in this study, hence the age is usually specified in years (in months for a few young children), referring to the nearest birthday. Age 10 thus means that the individual is over $9\frac{1}{2}$ and under $10\frac{1}{2}$ years. In the fourth column is indicated the hand (and arm) whose measures are given, "R" meaning the right hand and "L" the left. In the fifth column is given the length of the ulna-plus; in the sixth, the circumference of the palm; in the seventh, the circumference of the wrist; in the eighth, the

* A skeleton is known as unpieced if all the bones are taken from the same body. Commercial skeletons are often pieced.

length of the humerus; in the ninth, the circumference of the forearm relaxed; and in the tenth, the circumference of the forearm contracted. In the eleventh column is given the percentage of the forearm muscle-swell (computed by dividing the difference of the relaxed and the contracted muscle measures by the relaxed measure). In the twelfth and thirteenth columns are given the circumferences of the arm relaxed and contracted, respectively; and in the fourteenth column is given the percentage of arm muscle-swell (found by dividing the difference of the relaxed and the contracted muscle measures by the relaxed measure). In the last column are given explanatory notes.

[The measures are recorded in inches, with all fractions of the inch expressed in sixteenths. Since the denominator of every fraction may be understood to be sixteen, no denominator is written but it is indicated by the colon. Any figure following the colon indicates so many sixteenths of an inch. Thus 14:8 means 14 8-16 inches, and 6:14 means 6 14-16 inches. This system of recording has been adopted for convenience in tabulating. In reading the records it will be of further material assistance for the reader to remember that the record for the right hand is always given in the first of the two lines of measures across the page, and the record for the left hand is given in the second.]

List No. 1.

No	Sex.	Age.	Hand.	Una-Plus.	Palm.	Wrist.	Humerus.	Forearm Relaxed.	Forearm Contracted.	% of Swell (Forearm).	Arm Relaxed.	Arm Contracted.	% of Swell (Arm).
1.....	F	22	R 14:8 L 14:4	7:2 6:14	6:2 6:	12:8 12:4	8:2 7:14	8:6 8:1	8:6 8:1	2: 2.4	7:14 7:12	8:5 8:1	5.5 4.
2.....	F	21	R 14:10 L 14:8	7:12 7:12	6:4 6:4	13:2 13:	10: 9:12	10:7 10:1	10:7 10:1	4.4 3.2	9: 8:14	10: 9:12	11.1 9.9
3.....	M	20	R 16:10 L 16:8	8:8 8:4	7: 6:12	15:6 15:4	11:2 11:	11:12 11:8	11:12 11:8	5.6 4.6	12: 11:8	13:8 12:12	12.5 10.9
4.....	F	23	R 14:6 L 14:3	7:2 7:	5:12 5:9	13:4 13:2	8: 7:11	8:6 8:	8:6 8:	4.7 4.1	7:8 7:4	8:5 7:15	10.8 9.5
5.....	F	20	R 14:2 L 14:	7:2 7:	5:10 5:6	13: 12:10	8:2 8:1	8:8 8:6	8:8 8:6	4.6 3.9	8:8 8:4	9:8 9:2	11.8 10.6
6.....	F	19	R 14:8 L 14:6	6:12 6:10	5:6 5:8	13:12 13:12	8:8 8:4	8:14 8:8	8:14 8:8	4.4 3.	8: 7:12	8:12 8:6	9.4 8.1
7.....	F	21	R 14:8 L 14:4	7:10 7:	6:4 6:4	13:8 13:7	10:3 10:	10:9 10:5	10:9 10:5	3.7 3.1	12: 11:8	13:4 12:6	10.4 7.6
8.....	F	20	R 14:14 L 14:12	7:6 7:4	5:12 5:13	13:4 13:2	9:6 9:4	9:12 9:9	9:12 9:9	4. 3.4	9:7 9:4	10:7 10:3	10.6 10.1
9.....	F	19	R 14:6 L 14:5	7:4 7:	5:12 5:11	13:6 13:	8:8 8:4	8:12 8:7	8:12 8:7	2.9 2.3	9:8 9:4	10:4 9:14	7.9 6.8
10.....	F	18	R 14:12 L 14:10	7:8 7:4	6:4 6:2	13: 12:12	9:8 9:7	9:14 9:11	9:14 9:11	3.9 2.6	10:4 10:2	11:1 10:10	7.9 4.9
11.....	M	22	R 15:10 L 15:8	8:2 7:15	7:2 7:	14:6 14:5	10:9 10:1	10:14 10:5	10:14 10:5	2.9 2.5	10:2 10:	10:12 10:8	6.2 5.

All individuals are right handed unless otherwise specified in this column.

12.....	M	25	R	15:12	9:4	7:12	14:1	11:6	11:13	3.8	11:12	13:	10:6
			L	15:9	9:2	7:10	14:	11:5	11:10	2.8	11:10	12:8	7:5
13.....	M	23	R	16:6	8:12	6:14	14:11	10:4	10:9	3.	10:5	11:	6:7
			L	16:1	8:7	6:11	14:9	10:	10:4	2.5	10:2	10:10	4:9
14.....	F	19	R	15:1	7:11	5:13	14:	9:5	9:12	4.7	10:	11:	10:
			L	14:12	7:5	5:11	13:14	9:2	9:7	3.4	9:14	10:12	8:9
15.....	M	20	R	14:8	7:8	6:6	13:4	8:8	8:15	5.1	8:2	9:3	13:1
			L	14:4	7:4	6:6	13:	8:4	8:10	4.5	8:1	9:	11:6
16.....	F	21	R	13:4	7:	5:6	12:2	8:6	8:11	3.7	8:6	8:14	6.
			L	13:2	6:6	5:4	12:	8:4	8:7	2.3	8:4	8:10	4:5
17.....	F	22	R	15:	7:2	6:	13:12	9:8	9:13	3.3	9:12	10:6	6:4
			L	14:12	7:	5:14	13:8	9:2	9:6	2.7	9:8	10:	5:3
18.....	F	21	R	14:2	7:	5:12	13:8	8:6	8:9	2.2	9:	9:8	5:6
			L	14:4	7:2	6:	13:10	8:8	8:12	2.9	9:4	9:13	6:1
19.....	F	20	R	14:12	7:2	5:12	13:10	8:8	8:14	4.4	9:	9:8	5:6
			L	14:10	6:14	5:10	13:7	8:6	8:10	3.	8:14	9:4	4:2
20.....	M	23	R	15:8	8:2	6:8	14:4	10:4	10:12	4.9	9:14	11:	11:4
			L	15:6	8:	6:8	14:5	10:2	10:8	3.7	9:12	10:11	9:6
21.....	F	18	R	15:	7:4	6:	13:10	9:	9:5	3.5	9:	9:12	8:3
			L	14:12	7:2	6:	13:6	8:12	9:	2.9	8:14	9:6	5:6
22.....	F	17	R	12:2	6:8	5:12	11:10	8:4	8:12	6.1	8:4	9:2	10:6
			L	12:	6:6	5:10	11:6	8:2	8:8	4.6	8:2	8:13	8:5
23.....	F	18	R	12:4	6:4	5:3	11:4	7:6	7:11	4.2	7:2	7:9	6:1
			L	12:	6:2	5:2	11:3	7:4	7:8	3.4	7:1	7:6	4:4
24.....	F	30	R	13:12	7:4	5:14	12:14	8:4	8:8	3.	9:14	10:7	5:7
			L	13:8	7:2	5:12	12:12	8:	8:3	2.3	9:9	10:	4:6
25.....	M	18	R	14:4	7:	5:11	12:10	7:8	7:13	4.2	8:	8:10	7:8
			L	14:8	7:5	5:12	12:13	7:12	8:4	6.5	8:8	9:4	8:9
26.....	F	15	R	11:10	6:8	5:10	10:12	7:1	7:5	3.5	6:8	7:	7:7
			L	11:6	6:4	5:7	10:10	7:	7:3	2.7	6:4	6:10	6.

Left handed.

Left handed.

List No. 1—Continued.

No.	Sex.	Age.	Hand.	Ulna-Plus.	Palm.	Wrist.	Humerus.	Forearm Relaxed.	Forearm Contracted.	% of Swell (Forearm).	Arm Relaxed.	Arm Contracted.	% of Swell (Arm).
27.....	M	14	R 11:4 L 11:4	6:1	5: 10:1 6: 4:15 10:	6:12 7:2 6:11 7: 4:6	5:5 6:4 4:4 6:3	6:13 9: 6:10 7: 5:4	9: 6:13 7: 6:10 7: 5:4				
28.....	F	18	R 14:4 L 14: 7:	7:4 5:12 13:6 7: 5:13 13:4	8:8 8:14 8:7 8:12	3:7 9:8 3:9 9:14	4:4 10: 3:7 9:8	10:8 5: 9:14 3:9	5: 7:4 5: 7:4				
29.....	M	12	R 10:8 L 10:6	5:9 4:12 9:6 5:8 4:9 9:4	6:8 6:13 6:6 6:10	3:9 6:4 3:9 6:4	4:8 6:12 3:9 6:4	7:4 6:11 5: 6:11	7:4 5: 5: 6:11				
30.....	M	14	R 12:14 L 12:10	6:8 5:3 12: 6:6 5:3 12:	7:9 8: 7:4 7:9	4:3 7: 4:3 7:	5:6 7:1 4:3 7:	13:3 11:7 8: 7:13	13:3 11:7 8: 7:13				
31.....	F	11	R 11: 6:2 L 10:14	6:2 4:14 10:6 6: 4:12 10:4	7: 7:5 6:12 7: 3:7	6:4 6:9 6:4 6:9	6:5 6:12 6:4 6:9	6:9 5: 6:9 5:	6:9 5: 6:9 5:				
32.....	M	13	R 12:4 L 12:2	6:8 5:2 11:6 6:6 5: 11:4	7: 7:6 6:12 7:1	4:6 6:4 6:12 7:1	5:4 6:6 4:6 6:4	7:1 10:7 8: 6:12	7:1 10:7 8: 6:12				
33.....	M	7	R 10:12 L 10:10	5:12 4:6 9:14 5:8 4:8 9:11	6:14 7:2 6:11 6:8	3:6 6:11 2:9 6:8	7: 7:7 7: 7:7	8:4 8: 8:4 8:	8:4 8: 8:4 8:				
34.....	M	14	R 12: 6:10 L 11:12	6:7 5:8 11:2 6:7 5:4 10:14	7:7 7:12 7:6 7:10	3:4 7:6 3:4 7:6	4:2 7:8 4:2 7:8	13:3 11:9 10:5 8:2	13:3 11:9 10:5 8:2				
35.....	M	14	R 11:2 L 11: 6:8	6:10 4:7 9:8 6:8 4:8 9:6	7:1 7:6 7: 7:4	3:6 7:10 3:6 7:10	4:4 7:12 6: 6:1	10:5 8:4 11: 6:12	10:5 8:4 11: 6:12				
36.....	M	12	R 11: 5:10 L 10:14	5:8 4:10 10:2 5:8 4:10 10:2	6:4 6:10 6:3 6:8	5:1 6: 5:1 6:	6: 6:1 6: 6:1	8:3 8:3 8:3 8:3	8:3 8:3 8:3 8:3				
37.....	F	12	R 10:10 L 10:8	5:13 4:10 10:2 5:8 4:8 9:14	6:4 6:12 6: 6:6	8: 5:13 6:2 6:2	6:12 6:4 6: 6:6	10:8 8:7 6:4 8:7	10:8 8:7 6:4 8:7				

38.....	M	12	R 12: L 12:	6:4 6:4	5:3 5:	10:12 10:10	7:4 7:3	7:9 7:7	4.3 3.5	6:8 6:6	7:4 7:	11.5 9.8
39.....	F	11	R 11:4 L 11:1	5:12 5:8	4:12 10:4 4 12 10:4	6:4 6:2	6:4 6:2	6:10 6:7	6: 5.1	6:4 6:3	6:12 6:9	8: 6.1
40.....	F	12	R 12:4 L 12:2	6:8 6:4	5:6 5:5	11:4 11:2	7:8 7:6	7:14 7:10	5: 3.4	7:2 7:	8: 7:12 10:7	12.3 10.7
41.....	M	12	R 14:8 L 14:4	8: 7:6	6:6 6:5	13:4 13:3	8:8 8:4	8:12 8:7	2.9 2.3	8:2 8:1	9:2 9:	12.3 11.6
42.....	F	12	R 12:10 L 12:10	6:6 6:4	5:2 5:	11:10 11:6	7:8 7:6	7:12 7:9	3.3 2.5	7: 6:12	7:12 10:7 7:6	10.7 9.3
43.....	F	35	R 15: L 14:12	7:4 7:3	6: 6:	13:10 13:6	9: 8:12	9:6 9:	4.2 2.8	9: 8:14	9:14 9:6	9.7 5.6
44.....	F	19	R 14:4 L 14:	8: 7:11	6:5 6:3	13:8 13:3	9:8 9:4	9:13 9:7	3.3 2.	9:12 9:8	10:3 9:14	4.5 3.9
45.....	M	11	R 11:8 L 11:7	6:3 6:1	4:13 10:14 4:12 10:12	7: 6:10	7:6 6:14	5:3 3.8	6: 6.4	6:6 6:14 10:	7:2 6:14 10:	11.8 10.
46.....	F	11	R 13: L 12:12	6:7 6:5	5:1 5:1	12:1 12:	6:11 6:10	6:15 6:13	3:7 2.8	6:1 6:	6:11 6:8	10.3 8.3
47.....	M	12	R 11:8 L 11:7	6:4 6:2	5:4 5:1	10:10 10:6	6:12 6:10	7:4 7:	7.4 5.9	6:10 6:5	7:8 7:	13.2 10.9
48.....	M	14	R 12:2 L 12:3	6:8 6:2	5:1 5:	11:8 11:2	6:14 6:12	7:5 7:1	6:4 4.6	6:14 6:10	7:14 7:8	14.6 13.2
49.....	M	13	R 12:12 L 12:10	6:14 6:12	5:12 12:1 5:11 12:	8:4 8:	8:10 8:4	4:5 3.1	4.5 3.1	7:10 7:7	8:8 8:3	11.5 10.1
50.....	F	22	R 13:14 L 13:6	6:12 6:10	5:12 12:12 5:10 12:8	8: 7:14	8:4 8:1	3:1 2.4	8: 2.4	8:8 8:	9:2 8:8	7.4 6.3
51.....	F	19	R 14:2 L 13:15	7:4 7:2	6:3 6:1	13: 12:14	9:6 9:2	9:12 9:7	4: 3.4	10:2 9:15 10:6	10:12 10:6	6.2 4.4
52.....	F	22	R 14:3 L 14:1	7:2 7:	5:12 12:11 5:12 12:10	8:8 8:	8:12 8:3	2.9 2.3	8:11 8:10	9:8 9:	5.8 4.3	

List No. 1—Continued.

No.	Sex.	Age.	Hand.	Ulna-Plus.	Rad. Im.	Wrist.	Humerus	Forearm Relaxed.	Forearm Contracted.	% of Swell (Forearm).	Arm Relaxed.	Arm Contracted	% of Swell (Arm).
53.....	F	20	R	13:13 L 13:12	7:6	5:8 5:6	12:10 12:9	8:8 8:	8:12 8:3	2:9 2:3	8:8 8:6	9:4 9:	8:9 7:5
54.....	M	20	R	16:2 L 15:8	8:4 8:	6:14 6:12	14:8 14:4	9: 8:12	9:8 9:2	5:5 4:3	8:8 8:2	9:12 9:3	14:7 13:1
55.....	F	19	R	15:10 L 15:8	8: 7:12	6: 5:14	14:6 14:4	9:8 9:	9:14 9:4	3:9 2:8	9:4 9:	10:2 9:12	9:5 8:3
56.....	F	19	R	13:8 L 13:5	7: 6:12	5:12 5:10	12:12 12:10	8:1 8:	8:5 8:3	3:1 2:3	8:4 8:2	8:10 8:6	4:5 3:1
57.....	F	18	R	14:4 L 14:1	7:2 7:1	5:12 5:10	13:12 13:13	8: 7:12	8:6 8:	4:7 3:2	8:2 8:	8:10 8:6	6:2 4:7
58.....	M	18	R	14: L 13:12	7: 6:12	5:14 5:10	13:1 13:	8: 7:12	8:6 8:	4:7 3:2	8:4 8:	9:3 8:10	11:4 7:8
59.....	F	23	R	14: L 13:8	7:6 7:4	5:10 5:8	12:12 12:8	8:8 8:4	8:12 8:7	2:9 2:3	8: 7:14	8:6 8:2	4:7 3:2
60.....	F	29	R	14:1 L 14:	7:4 7:	5:8 5:6	12:12 12:9	8:4 8:	8:10 8:5	4:5 3:9	8:8 8:2	9: 8:9	5:9 5:4
61.....	M	20	R	16: L 15:12	8:8 8:4	6:12 6:11	14:14 14:1	9:8 9:	9:14 9:5	3:9 3:5	9:12 9:2	10:15 10:1	12:2 10:3
62.....	M	18	R	15:10 L 15:8	8:4 8:	6:14 6:12	14:8 14:4	9: 8:12	9:8 9:2	5:5 4:3	8:8 7:2	9:12 8:	14:7 12:3
63.....	F	27	R	15:12 L 15:12	8:8 8:	6:15 6:13	14:2 14:	9:12 9:4	10:6 9:12	6:4 5:4	9:4 9:	10:4 9:12	10:8 8:3

64.....	F	16	R	12.4 L 12.6	6: 5.4	5.4 11.1 5.4 11.4	7: 6.14	7.6 7.2	5.4 3.6	6.12 6.10	7.4 7:	7.4 5.9	Left handed in childhood. Transferred to right hand by parental interference.
65.....	F	17	R	11.2 L 10.14	6.12 6.4	4.14 10.2 4.14 10.2	6.8 6.8	6.15 6.12	4.7 3.8	6.10 5.12	10.4 6.9	6.9	
66.....	F	14	R	11: L 10.12	6.4 6.2	4.15 10.6 4.14 10.2	7.2 7:	7.6 7.3	3.5 2.7	6.10 6.8	7.4 7:	7.7 7.7	
67.....	F	15	R	12.6 L 12.5	6.5 6.3	5.6 11.10 5.4 11.9	7: 6.12	7.6 7:	5.4 3.7	7.5 7.3	7.14 7.9	7.7 5.2	
68.....	M	18	R	16.8 L 16.4	8: 7.10	6.12 14.8 6.10 14.4	9.10 10: 9.4 9.8	3.9 2.7	9.2 9:	10.4 9.15	12.3 10.4	12.3	
69.....	F	17	R	14.4 L 14.1	6.12 6.10	5.8 13.12 5.8 13:	8.10 8.4	8.15 8.8	3.6 3:	8: 7.10	7.8 8.1	7.8 5.7	
70.....	F	17	R	13.4 L 13:	6.10 6.8	5.8 12.4 5.4 12:	9: 8.11	9.6 8.15	4.2 2.9	7.14 7.10	8.10 8.4	9.4 8.2	
71.....	F	17	R	13.6 L 13.4	7: 6.8	5.4 12.2 5.3 11.13	8.6 8.4	8.9 8.6	2.2 1.5	8.6 8.4	8.12 8.8	4.5 3:	
72.....	M	16	R	12: L 11.13	6.15 6.11	5.11 11.4 5.9 11:	8.4 8.2	8.12 8.8	6.1 4.6	8.4 8.1	9.2 8.10	10.6 7:	
73.....	F	16	R	10.4 L 9.15	6.8 6.7	5.4 9.12 5.4 9.8	6.9 6.8	6.14 6.12	4.8 3.8	6.6 6.4	7.3 6.15	12.7 11:	
74.....	M	18	R	15.6 L 15.4	8.3 8.1	6.6 14.6 6.5 14.4	10.1 9.15	10.9 10.5	5: 3.8	9.15 9.13	11.5 11:	13.8 12.1	
75.....	M	18	R	15.10 L 15.5	8.5 8.2	6.8 14.8 6.6 14.5	10.4 10.2	10.10 10.6	3.7 2.5	9.15 9.14	11.4 10.14	13.3 10.1	
76.....	F	14	R	10.8 L 10.6	5.9 5.7	4.10 9.9 4.9 9.10	9.9 9.10	6.12 6.10	2.9 3.8	6.2 6.4	6.6 6.10	4.1 6:	Transferred from right to left hand by broken right humerus at 4 years.
77.....	M	14	R	10.14 L 10.13	6.4 6.2	4.9 9.15 4.8 9.13	6.10 6.8	7: 6.12	5.7 3.8	6.6 6.13	7.4 10.1	13.7 10.1	
78.....	F	14	R	10.9 L 10.8	5.8 5.6	4.10 9.7 4.9 9.4	9.7 6.7	6.8 6.11	5.8 3.9	6.4 6.2	6.12 6.7	8: 5.1	

Transferred from right to left hand by broken right humerus at 4 years.

List No. 1—Continued.

No.	Sex.	Age.	Hand.	Ulna-Plus.	Palm.	Wrist.	Humerus.	Forearm Relaxed.	Forearm Contracted.	% of Swell. (Forearm).	Arm Relaxed.	Arm Contracted.	% of Swell. (Arm).
79.....	F	20	R L	14:4 14:3	7:9 7:6	6: 6:	13:5 13:2	9:10 9:7	9:15 9:10	3.2 2.	9:12 9:6	10:10 10:7	9. 6.7
80.....	M	16	R L	12:14 12:10	6:8 6:6	5:4 5:3	12:2 12:	7:10 7:4	8:3 7:10	7.4 5.2	7:1 7:	8: 7:12	13.3 10.7
81.....	M	22	R L	15:12 15:10	8:4 8:	6:6 6:4	14:12 14:9	10:4 10:2	10:10 10:6	3.7 2.5	9:14 9:8	11:2 10:8	12. 10.5
82.....	M	22	R L	15:10 15:6	8:6 8:4	6:8 6:7	14:12 14:10	10:2 9:14	10:9 10:3	4.3 3.2	9:12 9:10	11: 10:9	12.8 9.7
83.....	M	25	R L	15:12 15:8	8:4 8:2	6:4 6:3	14:12 14:9	10: 9:14	10:6 10:2	3.8 2.5	9:6 9:	10:9 10:	12.7 11.1
84.....	M	22	R L	15:8 15:4	7:14 7:10	6: 5:15	13:14 13:10	9:12 9:8	10:2 9:12	3.8 2.6	9: 8:12	10:8 9:13	16.7 12.1
85.....	M	23	R L	15:10 15:4	8:4 8:	6:4 6:2	14:8 14:5	10:6 10:2	10:15 10:8	5.4 3.7	9:8 9:2	10:12 10:1	13.2 10.3
86.....	M	27	R L	15:12 15:8	8:8 8:4	6:10 6:5	15: 14:14	10:10 10:8	11:2 10:14	4.7 3.6	9:14 9:10	11:6 10:12	15.2 11.7
87.....	M	24	R L	15:10 15:4	8:6 8:4	6:8 6:6	14:12 14:10	10:8 10:7	10:15 10:12	4.1 3.	9:12 9:8	11: 10:7	12.8 9.9
88.....	M	23	R L	15:14 15:10	8:10 8:8	6:8 6:5	14:14 14:11	10:6 10:4	10:12 10:8	3.6 2.4	9:14 9:10	11:3 10:10	13.2 10.4
89.....	M	21	R L	15:10 15:8	8:10 8:4	6:8 6:6	14:8 14:6	10:4 10:2	10:9 10:6	3. 2.5	9:8 9:6	10:11 10:4	12.5 9.3

90.....	M	23	R	15:14 15:12	8:12 8:10	6:11 14:10 6:10 14:8	10:14 11:4 10:10 10:14	3.5 2.4	10: 10:14	11: 10:10	10: 7.6
91.....	M	22	R	15:14 15:10	8:10 8:8	6:14 14:12 6:11 14:11	10:8 10:5	3.6 2.4	9:10 9:8	10:14 10:4	13. 7.9
92.....	M	19	R	15:8 15:4	8:8 8:6	6:6 14:10 6:5 10:6	10:11 10:2	3. 2.5	9:8 9:6	10:15 10:6	15.1 10.7
93.....	M	24	R	15:10 15:4	8:10 8:6	7:2 14:12 7:1 14:9	10:4 10:2	3. 2.5	9:6 9:2	10:1 9:9	7.3 4.8
94.....	F	18	R	14:6 14:2	7:8 7:3	6: 6:	13:6 13:4	9:1 8:14	2.8 2.1	9:8 8:12	5.6 9:1
95.....	F	20	R	13:10 13:8	7:2 6:12	5:9 5:8	12:12 12:9	8:5 8:	2.3 1.6	8:14 8:2	6. 4.6
96.....	F	22	R	14:15 14:13	7:11 7:6	6:3 6:3	13:10 13:6	9:1 8:15	2.1 1.4	10:2 9:15	10:9 10:5
97.....	F	21	R	14:8 14:5	7:9 7:4	5:14 5:12	13:6 13:6	9:3 8:14	4.1 2.8	9:8 9:2	5.3 4.1
98.....	F	19	R	13:5 13:3	7:3 7:	5:15 5:14	12:4 12:1	9:1 9:	2.8 2.1	10:8 9:14	5. 10:5
99.....	F	18	R	14: 14:2	7:3 7:7	5:11 5:11	13: 13:3	8:4 8:8	3.8 2.9	9:4 9:8	9:10 9:15
100.....	M	21	R	17: 16:14	9: 8:14	7:4 7:2	15:6 15:4	10:12 10:10	3.5 2.9	9:10 9:4	10:6 5.4
101.....	F	20	R	12:8 12:8	6:8 6:4	5:8 5:7	11:8 11:6	7:8 7:6	7:14 7:10	5. 3.4	7:6 7:10
102.....	F	21	R	6:10 6:8	5:8 5:6	4:4 4:2	6:1 6:				
103.....	M	21	R	6:12 6:11	5:9 5:7	4:5 4:4	6:3 6:1				
104.....	M	4	R	9:6 9:4	5:6 5:1	4:10 4:9	8:10 8:9	6:14 6:12	7:1 6:14	2.7 1.9	7:9 7:5

Left handed as a child. Forced to use right hand. Stammerer, beginning at 6 years.

List No. 1—Continued.

No.	Sex.	Age.	Hand.	Una-Plus.	Palm.	Wrist.	Humerus.	Forearm. Relaxed.	Forearm. Contracted.	% of Swell. (Forearm).	Arm Relaxed.	Arm Contracted.	% of Swell (Arm).	
105.....	M	7	R L	10:3 10:5	5:11 5:14	5:1 5:1	9: 9:1	5: 5:	5:4 5:3	5: 3.8	6:10 6:9	6:15 6:13	4.7 3.8	Left handed as a child, but forced by parents to use right hand. Began stammering at 5 years.
106.....	F	5	R L	8:6 8:3	4:8 4:6	4:2 3:14	7:5 7:3	5:10 5:8	5:12 5:9	2.2 1.1	5:10 5:8	5:14 5:11	4.4 3.4	
107.....	F	7	R L	10:3 10:2	5:1 5:1	4:10 4:9	9:5 9:2	6:4 6:2	6:6 6:3	2. 1.	5:15 5:14	6:3 6:1	4.2 3.2	
108.....	M	2	R L	7:15 7:13	4:8 4:7	4:1 4:	6:8 6:2							
109.....	F	12	R L	13:11 13:9	7:1 6:12	5:14 5:12	13: 12:12	8:2 8:	8:5 8:2	2.3 1.6	8:8 8:3	9:1 8:10	6.6 5.3	
110.....	F	83	R L	13:10 13:4	7:2 6:12	5:10 5:10	12:4 12:1	8:6 8:4	8:9 8:6	2.2 1.5	9:4 9:1	9:9 9:5	3.4 2.8	
111.....	F	47	R L	14:8 14:6	7:2 6:10	5:7 5:6	13:5 13:3	7:4 7:2	7:12 7:8	6.9 5.3	8:3 8:	8:14 8:9	8.4 7.	
112.....	F	60	R L	15: 14:11	7:12 7:4	6:4 6:	14: 13:15	8:10 8:6	8:14 8:8	2.9 1.5	9: 8:12	9:8 9:2	5.6 4.3	
113.....	M	25	R L	16:6 16:5	8:4 8:	6:8 6:8	15:2 14:13	9:10 9:8	10:1 9:14	4.5 3.9	10:4 10:	11:8 10:14	12.2 8.8	
114.....	F	55	R L	14:9 14:9	7:14 7:10	6:2 6:1	12:12 12:10	9:8 9:2	9:12 9:5	2.6 2.	10: 9:12	10:8 10:2	5. 3.8	
115.....	F	20	R L	13:6 13:	6:8 6:4	5:3 5:2	12:4 12:1	7:9 7:8	7:14 7:12	4.1 3.3	8:4 8:2	8:12 8:8	6.1 4.6	

116.....	F	27	R	14:4 14:1	7:6 5:9	5:10 13:8	8:1 7:	8:4 7:2	2:3 1.8	8:8 8:6	9: 8:12	5:9 4.5
117.....	F	20	R	13:14 13:10	7:5 7:1	5:12 5:11	13:2 13:	8:15 8:11	2.1 1.5	9:13 9:10	10:6 10:1	5.7 4.5
118.....	M	20	R	15:3 15:1	8:7 8:2	6:14 6:10	13:15 13:12	10:14 10:10	4.6 11:	11: 10:15	11:15 11:12	8.5 7.4
119.....	M	13	R	13:13 13:13	7:4 7:	5:12 5:10	12:13 12:13	8: 7:8	6.3 5.8	7:2 7:	7:14 7:10	10:5 8.9
120.....	M	3	R	12:4 12:	6:12 6:10	5:10 5:8	11:8 11:2	8: 7:14	3.1 1.6	8: 7:12	8:9 8:3	7. 5.6
121.....	M	10	R	12:3 11:15	6:9 6:6	5:8 5:6	11:1 10:15	7:14 7:8	2.4 3.3	7:14 7:14	8:4 8:6	4.8 6.4
122.....	M	14	R	14:13 14:11	7:10 6:	6:8 6:6	13:9 13:5	8:12 8:5	3.2 3.8	8:14 8:12	9:9 9:6	7.7 7.1
123.....	F	9	R	12:8 12:5	6:2 6:1	5:4 5:4	11:2 11:2	7:5 7:5	7.7 7.6	7:7 7:6	8: 7:12	7.6 5.1
124.....	F	9	R	11:2 10:14	6:7 6:5	5:4 5:3	10:7 10:3	7:5 7:5	7.8 7.7	7:4 7:7	7:15 7:10	9.5 6.1
125.....	M	6	R	10:9 10:8	5:6 5:5	4:11 4:10	9:12 9:10	6:12 6:11	2.8 1.9	6:4 6:2	6:10 6:6	6. 4.1
126.....	M	11	R	12:13 12:10	6:12 6:12	5:5 5:5	11:14 11:13	7:13 7:11	4. 2.4	6:15 7:6	7:10 7:6	9:9 9.6
127.....	M	8	R	9:11 9:8	5:9 5:8	4:14 4:12	8:10 8:9	7:2 7:2	2.6 1.8	6:13 6:13	7:4 7:3	6.4 5.5
128.....	F	7	R	10:9 10:5	5:11 5:9	4:7 4:7	9:11 9:7	5:14 5:13	3.2 2.1	5:12 5:10	6:3 5:15	7.6 5.6
129.....	F	4	R	8:14 8:12	5:3 5:2	4:11 4:10	8:1 8:	6:2 6:1	4.1 3.1	6:4 6:2	6:10 6:7	6. 5.1
130.....	F	6	R	10:1 9:14	5:13 5:10	5:2 5:	9:7 9:4	7:2 7:	2.6 1.8	7: 6:14	7:7 7:2	6.3 3.6

Adopted left hand on account of elbow injury at 5 years.

Stammerer since afflicted with measles at 9 years.

List No. 1—Continued.

No.	Sex.	Age.	Hand.	Una-Plus.	Forearm. Relaxed.	Wrist.	Humerus.	Forearm Contracted	% of Swell (Forearm).	Arm Relaxed.	Arm Contracted	% of Swell (Arm).
131.....	M	6	R L	11:1 10:15	6:6 6:2	5:4 5:3	10:3 10:1	7:2 7:1	7:5 7:3	2:6 1:8	7:9 7:6	8. 6.3
132.....	M	6	R L	10:5 10:3	5:11 5:9	4:12 4:11	9:3 9:2	6:8 6:7	6:12 6:10	2:8 2:9	6:6 6:4	7.8 7.
133.....	M	5	R L	9:8 9:7	5:8 5:5	4:10 4:10	8:11 8:4	6:5 6:2	6:8 6:4	3. 2.	6:3 6:1	7. 6.2
134.....	F	35	R L	14:12 14:5	7:1 6:4	5:13 5:12	12:15 12:14	8:9 8:6	9:3 8:14	7:3 6.	9:6 9:10	10. 6.9
135.....	F	49	R L	14:9 14:7	7: 6:10	6:1 5:12	13:11 13:9	9:7 9:	9:14 9:6	4:6 4:2	11: 10:11	6.8. 5.9
136.....	F	7	R L	10:10 10:10	6:2 5:14	4:14 4:13	9:12 9:9	6:10 6:9	6:13 6:11	2:8 1.9	6:4 6:2	4. 3.1
137.....	F	8	R L	11:10 11:6	6:2 6:	5: 5:	10:9 10:7	7:2 6:13	7:5 6:15	2:6 1.9	7:9 7:5	5. 3.4
138.....	F	15	R L	13:8 13:8	6:14 6:8	5:6 5:6	12:11 12:8	7:6 7:	7:11 7:4	4:2 3:6	7:12 7:8	7.3 5.8
139.....	F	12	R L	12:8 12:2	6:12 6:8	5:9 5:8	11:12 11:9	7:5 7:3	7:9 7:6	3:4 2:6	7:2 7:4	5.3 3.6
140.....	F	8	R L	11:7 11:6	6:3 6:2	5:4 5:4	10:7 10:6	7:3 7:4	7:6 7:6	2:6 1.7	7: 6:14	4.5 2.7
141.....	F	9	R L	10:14 10:13	6:5 6:2	5:5 5:4	10:3 10:2	7:4 7:3	7:8 7:6	3:4 2:6	7:9 7:6	5.6 4.2

142.....	F	11	R	13:5 13:2	6:13 6:10	5:10 5:9	12:9 12:7	8:4 8:2	8:8 8:5	3. 2.3	8:1 8:	8:8 8:5	5.4 3.9
143.....	M	13	R	13:4 13:1	7:5 7:2	6: 5:15	12:12 12:9	8:4 8:	8:9 8:4	3.8 3.1	8:7 8:3	8:9 8:9	6.7 4.6
144.....	M	11	R	13: 12:14	6:14 6:12	5:10 5:11	12:7 12:4	7:7 7:4	7:11 7:7	3.4 2.6	8:1 7:13	8:10 8:4	7. 5.6
145.....	F	11	R	12:3 12:1	6:4 6:1	5:5 5:4	11:7 11:8	7:5 7:4	7:9 7:7	3.4 2.6	7:3 7:	7:8 7:4	4.3 3.6
146.....	M	7	R	10:12 10:10	6:4 6:	5:4 5:2	9:4 9:2	7:4 7:2	7:7 7:4	2.6 1.8	7: 6:14	7:5 7:2	4.5 3.5
147.....	M	18 da.	R	5:1 5:	3:11 3:10	3:4 3:3	4:3 4:1	4:3 4:2			4:2 4:1		
148.....	M	9	R	11:12 11:10	6:14 6:12	5:8 5:6	11:4 10:14	7:10 7:6	7:14 7:9	3.3 2.6	7:12 7:9	8:3 7:15	5.6 5.
149.....	F	9	R	11:10 11:8	6:4 6:	5:2 5:	10:8 10:4	7:4 7:2	7:7 7:4	2.6 1.8	7:1 7:	7:7 7:5	5.3 4.5
150.....	F	9	R	11:10 11:8	6:4 5:15	5:2 5:1	10:8 10:5	7:4 7:2	7:7 7:4	2.6 1.8	7:1 6:14	7:6 7:2	4.5 3.6
151.....	F	6	R	10:4 10:3	5:14 5:9	4:12 4:10	9:4 9:2	6:8 6:4	6:10 6:5	1.9 1.	6:4 6:2	6:8 6:5	4. 3.1
152.....	F	9	R	11:14 12:4	6:4 6:12	5:4 5:6	11:2 11:6	7:7 7:7	7:10 7:9	2.5 1.7	7:2 7:1	7:8 7:6	5.3 4.4
153.....	M	8	R	11:6 11:4	6:8 6:6	5:4 5:4	10:11 10:7	7:10 7:3	7:13 7:5	2.5 1.7	7:4 7:1	7:13 7:8	7.8 6.2
154.....	M	8	R	11:1 10:15	6: 5:9	4:15 4:12	10:1 10:	6:10 6:2	6:14 6:1	3.8 3.1	6:4 6:	6:10 6:4	6: 4.2
155.....	M	8	R	11:15 11:13	6:3 6:2	5:4 5:4	10:8 10:8	7:5 7:	7:9 7:3	3.4 2.7	7:1 6:14	7:8 7:3	6.2 4.5
156.....	F	5	R	9:8 9:5	5:5 5:3	4:10 4:10	8:14 8:10	6:10 6:10	6:13 6:12	2.8 1.9	6:4 6:1	6:9 6:5	5. 4.1

Left handed as a child, but transferred to
right hand by parents.

List No. 1—Continued.

Number.	Sex.	Age.	Hand.	Ulna-plus.	Palm.	Wrist.	Humerus.	Forearm Relaxed.	Forearm Contracted.	% of Swell (Forearm)	Arm Relaxed.	Arm Contracted	% of Swell (Arm).
157.....	F	16	R 13:4 L 13:	7: 6:12	5:4 5:4	12:1 12:	8:12 8:12	9:2 9:	4:3 2:9	9:4 9:2	9:4 9:2	9:12 9:8	5:4 4:1
158.....	M	14	R 14: L 13:12	7:4 6:12	5:12 5:12	13: 12:14	8:4 8:2	8:9 8:6	3:8 3:1	8:4 8:2	8:4 8:2	8:12 8:8	6:1 4:6
159.....	F	16	R 13:10 L 13:7	7: 6:12	6:4 6:1	12:8 12:7	9:6 9:	9:12 9:4	4: 2:8	10: 9:6	10:8 9:12	5: 4:	
160.....	M	16	R 14:2 L 14:	7:2 7:	6: 6:	13:4 13:2	8:12 8:8	9:1 8:12	3:6 2:9	8:12 8:8	9:6 9:	7:1 5:9	
161.....	M	16	R 13:11 L 13:7	8:8 8:1	6:1 6:	12:8 12:7	8:12 8:8	9:2 8:12	4:3 2:9	9:4 8:12	9:15 9:5	7:4 6:4	
162.....	M	16	R 14: L 14:	7:12 7:4	6:2 6:	12:14 12:11	9:8 9:	9:15 9:5	4:6 3:5	10:4 10:	11:3 10:12	9:1 7:5	
163.....	F	18	R 14:8 L 14:6	7:11 7:3	6:11 6:9	13:8 13:7	10: 9:12	10:5 10:	3:1 2:6	12: 12:	12:12 12:10	6:3 5:2	
164.....	M	15	R 14:10 L 14:6	7:4 6:12	5:8 5:8	13:14 13:11	8:4 8:	8:8 8:3	3: 2:3	8: 8:	8:12 8:8	9:4 6:3	
165.....	F	15	R 13:6 L 13:4	6:11 6:7	5:9 5:8	12:7 12:5	8:8 8:4	8:13 8:8	3:7 3:	9:8 9:4	10: 9:10	5:3 4:1	
166.....	F	14	R 13:8 L 13:5	6:12 6:11	5:8 5:7	12:6 12:5	8:12 8:8	9:1 8:12	3:6 2:9	9:4 9:2	9:12 9:8	5:4 4:1	
167.....	F	18	R 14:7 L 14:2	7: 6:12	5:12 5:10	13:7 13:4	10:2 9:12	10:8 10:	3:7 2:6	11: 11:	11:12 11:10	6:8 5:7	

List No. 1—Continued.

Number.	Sex.	Age.	Hand.	Una-plus.	Palm.	Wrist.	Humerus.	Forearm. Relaxed.	Forearm Contracted.	% of Swell (Forearm)	Arm Relaxed.	Arm Contracted.	% of Swell (Arm).
183.....	F	29	R	14:8	7:	5:11 5:9	12:7 12:1	8:12 8:8	9:3 8:13	3:7 3:9	9:1 8:14	9:15 9:9	9:7 7:7
184.....	F	30	R	14:4	6:9	5:11 5:10	12:11 12:7	8:12 8:8	9:1 8:12	3:6 2:9	9:3 8:12	9:12 9:4	6:1 5:7
185.....	F	26	R	14:11	7:5	6:1 6:	12:11 12:5	8:12 8:8	9:2 8:12	4:3 2:9	9: 8:14	9:12 9:8	8:3 7:
186.....	F	29	R	14:4	6:9	5:8 5:7	12:7 12:	8:8 8:7	8:14 8:11	4:4 3:	8:14 8:12	9:8 9:4	7: 5:7
187.....	F	20	R	13:14	7:5	6:2 6:	12:3 12:	8:12 8:	9:2 8:4	4:3 3:1	9: 8:12	9:8 9:3	5:6 5:
188.....	F	24	R	14:	6:8	5:8 5:7	12:7 12:3	9:4 8:12	9:9 9:	3:4 2:9	9:12 9:7	10:4 9:13	5:1 4:
189.....	M	23	R	14:15	8:7	6:11 6:10	12:7 12:4	8:12 8:8	9:2 2:9	4:3 2:9	9:4 9:1	10:8 10:2	13:5 11:7
190.....	F	19	R	11:	6:13	5:1 5:	12:13 12:8	8:12 8:12	9:2 9:	4:3 2:9	8:8 8:1	9:4 8:11	8:9 7:7
191.....	F	20	R	14:3	6:14	5:8 5:7	12:11 12:5	9:8 8:6	9:14 8:10	3:9 3:	10: 9:12	10:14 10:8	8:8 7:7
192.....	F	24	R	14:12	7:1	6:1 6:	12:7 12:3	8:12 8:	9:1 8:4	3:6 3:1	9: 8:12	9:12 9:6	8:3 7:1
193.....	F	27	R	15:	7:5	6: 6:	13:3 12:15	8:12 8:8	9:2 8:12	4:3 2:9	9:8 9:4	10:5 9:15	8:6 7:4

194.....	M	15	R	14:3	7:1	5:12 12:8	8:14	9:3	3.5	9:4	10:	8.1
			L	14:4	7:5	5:14 12:11	9:	9:6	4.2	9:8	10:8	10.5
195.....	F	22	R	14:8	6:13	5:14 12:13	9:8	9:13	3.3	10:	10:12	7.5
			L	14:4	6:8	5:13 12:9	8:6	8:10	3.	9:12 10:6	6:4	
196.....	F	28	R	14:8	6:12	5:12 12:12	8:12	9:1	3.6	8:8	9:4	8.9
			L	14:6	6:9	5:8 12:8	8:12	9:	2.9	8:3	8:12	6.9
197.....	M	17	R	14:3	7:2	5:11 12:9	9:	9:6	4.2	9:8	10:12 13:2	
			L	14:1	7:	5:10 12:2	8:14	9:3	3.5	9:4	10:4	10.8
198.....	M	27	R	15:2	8:2	6:8 13:8	9:12 10:8	7.7	9:4	10:12 16:2		
			L	14:11	7:8	6:4 13:3	9:8	10:	5.3	9:	10:4	13.9
199.....	M	17	R	13:14	7:8	6:4 12:2	9:	9:8	5.6	8:8	9:14 16:2	
			L	13:12	7:2	6:2 12:	8:10	9:1	5.1	8:6	9:8	13.4
200.....	F	18	R	14:1	7:1	5:11 12:7	8:8	8:14	4.4	8:14	9:8	7.
			L	14:	6:12	5:8 12:3	8:7	8:11	3.	8:12	9:4	5.7

Left handed.

LIST NO. 2—Left-Handed Individuals.

Number.	Sex.	Age.	Hand.	Una-plus.	Palm.	Wrist.	Humerus.	Forearm Relaxed.	Forearm Contracted.	% of Swell (Forearm)	Arm Relaxed.	Arm Contracted.	% of Swell (Arm).
1.....	M	15	R L	11:6 11:12	7: 7:1	5:8 5:9	10:4 10:6	7:7 7:8	7:12 7:14	4.2 5.	7: 7:1	7:14 8:	12.5 13.3
2.....	M	14	R L	11: 11:2	5:5 5:5	4:6 4:7	9:13 9:15	5:12 5:12	6: 6:1	4.3 5.6	5:8 5:10	6:1 6:5	10.2 12.2
3.....	M	12	R L	12: 12:	6: 6:2	4:11 4:11	10:10 10:11	6:8 6:8	6:12 6:13	3.8 4.8	5:12 6:	6:2 6:7	6.5 7.1
4.....	F	12	R L	12:10 12:14	6:8 6:10	5:13 5:13	10:11 10:11	7: 7:	7:4 7:5	3.6 4.5	7: 7:2	7:8 7:12	7.1 8.8
5.....	M	14	R L	11:12 11:12	5:10 5:12	4:8 4:12	11:2 11:3	6:4 6:5	6:8 6:10	4. 5.	6: 6:1	6:8 6:10	8.3 9.3
6.....	M	13	R L	12: 12:2	5:12 5:13	4:9 4:10	10:12 10:10	6:6 6:8	6:10 6:13	3.9 4.8	6:10 6:5	7:2 6:13	7.5 7.9
7.....	F	12	R L	10:14 11:4	5:12 5:14	4:13 4:14	10:2 10:3	6:8 6:10	6:11 6:14	2.9 3.8	6:8 6:9	7: 7:2	7.7 8.6
8.....	M	13	R L	11:4 11:8	5:9 5:12	4:8 4:9	10:8 10:9	6:2 6:4	6:7 6:10	5.1 6.	5:12 5:14	6:4 6:7	8.7 9.6
9.....	M	21	R L	14: 14:4	7: 7:6	5:13 5:11	13:2 13:6	8:2 8:3	8:7 8:9	3.8 4.6	8:12 8:12	9:12 9:14	11.4 12.9
10.....	M	16	R L	14:6 14:8	7: 7:3	5:4 5:6	13: 13:1	7:12 8:	8:1 8:6	4. 4.7	7:8 7:4	8:2 8:4	8.3 13.8
11.....	M	5	R L	9:8 9:9	6: 6:2	4:10 4:10	8:12 9:	6:8 6:10	6:9 6:12	1. 1.9	6:10 6:12	6:15 7:2	4.7 5.6

Parents tried to force use of right hand, but failed. Stammered for several years.

Left humerus broken at 8 years.

Parents tried to teach use of right hand, but did not succeed.

Parents and teachers tried to force use of right hand, but failed. Began stammering at 7 years.

12.....	M	7	R	10:8 L 10:10	5:12 6:	4:12 4:14	9:2 9:4	6:12 7:	6:14 7:3	1:9 2:7	6:14 7:	7:5 7:6	6:4 5:4
13.....	F	16	R	14:14 L 15:8	6:7 6:10	5:6 5:8	13: 13:	9:4 9:8	9:7 9:12	2: 2:6	9:8 9:12	9:15 10:5	4:6 3:8
14.....	F	20	R	13:11 L 13:13	7:10 7:12	6:3 6:4	13:1 13:1	9:4 9:8	9:7 9:12	2: 2:6	9:9 9:12	9:15 10:4	3:9 5:1
15.....	M	30	R	15:4 L 15:6	8:3 8:5	6:4 6:5	13:6 13:9	9:8 9:12	9:14 10:4	3:9 5:1	10:2 10:5	10:14 11:7	7:4 10:9
16.....	M	8	R	10:4 L 10:6	5:12 5:7	4:15 4:13	9:8 9:4	6:11 6:9	6:14 6:13	2:8 3:8	6:6 6:7	6:13 6:15	6:9 7:8
17.....	F	9	R	11:2 L 11:5	6:4 6:5	5:4 5:5	10:11 10:11	7: 7:2	7:2 7:5	1:8 2:7	7:2 7:3	7:8 7:11	5:3 6:9
18.....	F	14	R	13:8 L 13:8	7:2 7:5	5:10 5:11	12:1 12:2	8: 8:1	8:3 8:6	2:3 3:9	8:1 8:1	8:9 8:10	6:2 7:
19.....	M	17	R	15:14 L 16:	8:8 8:10	6:14 6:15	14:1 14:3	9:4 9:8	9:9 9:14	3:4 3:9	9:6 9:9	10:6 10:11	10:7 11:8
20.....	F	23	R	13:4 L 13:6	6:12 6:14	5:10 5:12	12: 12:3	7:12 8:	8: 8:6	3:2 4:7	8:4 8:4	8:10 8:12	4:5 6:1
21.....	M	21	R	14:14 L 15:	7:14 8:	6:2 6:2	12:12 12:15	9:2 9:4	9:8 9:12	4:1 5:4	8:14 9:4	10: 10:8	12:7 13:5
22.....	M	21	R	16:4 L 16:6	7:12 7:14	6:2 6:2	14: 14:3	9:1 9:2	9:6 9:8	3:4 4:1	9:12 10:	10:8 10:14	7:7 8:8
23.....	F	16	R	14: L 14:4	7:12 7:15	6:8 6:10	12:9 12:12	9:10 9:12	9:14 10:1	2:6 3:2	9:2 9:4	9:8 9:12	4:1 5:4
24.....	M	17	R	14:1 L 14:4	7:12 8:2	5:12 5:12	12:12 13:	8:12 8:14	9:1 9:4	3:6 4:2	9: 9:4	9:14 10:4	9:7 10:8
25.....	M	19	R	15:14 L 16:	7:9 7:11	6: 6:	13:12 13:14	9:4 9:6	9:8 9:12	2:7 4:	9:6 9:10	10:2 10:8	8: 9:1
26.....	F	14	R	10:15 L 11:	5:8 5:10	4:8 4:10	10:2 10:4	6:7 6:8	6:10 6:12	2:9 3:8	6: 6:2	6:6 6:9	6:2 7:1

Parents and teachers tried to teach use of right hand, but failed.

Parents tried to force use of right hand. Stammerer.

List No. 2—Left Handed Individuals—Continued.

Number.	Sex.	Age.	Hand.	Una-plus.	Palm.	Wrist.	Humerus.	Forearm Relaxed.	Forearm Contracted.	% of Swell (Forearm)	Arm Relaxed.	Arm Contracted	% of Swell (Arm).	
27.....	M	22	R L	14:8 14:10	7:4 7:12	5:10 13:1 5:12 13:7	8:4 8:5	8:9 8:11	3:8 4:5	3:8 4:5	8:8 8:8	9:5 9:8	9:6 11:8	Right humerus broken at 10 years.
28.....	M	28	R L	14:4 14:4	7:1 7:2	5:10 12:9 5:12 12:13	7:12 7:13	8:1 8:2	3:2 4	3:2 4	8:12 9	9:12 11:4 10:4 13:9	11:4 13:9	
29.....	F	33	R L	13:4 13:5	6:12 6:13	5:10 12:12 5:12 13:1	7:13 8	9:2 8:6	4 4:7	4 4:7	8:4 8:5	8:12 8:15	6:1 7:5	
30.....	M	24	R L	14:14 15	7:14 8:1	6:2 12:7 6:4 12:12	9:2 9:5	9:8 9:13	4:1 5:4	4:1 5:4	8:13 9:4	9:9 10:4	8:5 10:8	
31.....	M	20	R L	14:11 14:11	7:8 7:11	6:2 12:7 6:3 12:12	9:12 10: 9:14 10:4	2:6 3:8	10:3 10:4	11: 11:5	10:3 11:5	11: 10:4	8 10:4	Double transfer. Used right hand twelve years then went back to left since it seemed better. Stammered in early school.
32.....	M	25	R L	16:1 16:5	8:2 8:4	7:2 13:14 7:4 14:1	9: 9:14 10:7	4:9 5:7	9:7 9	4:9 5:7	9: 9	10:2 10:5	12:5 15:3	
33.....	F	19	R L	14:1 14:4	7: 7:3	5:7 12:9 5:10 12:12	8:4 8:7	8:8 8:13	3: 4:4	3: 4:4	9:2 9:4	9:15 10:4	8:9 10:8	
34.....	F	30	R L	14: 14:4	6:12 7:	5:9 12:4 5:13 12:8	7:11 8:	8:6 4:7	4:1 4:7	8:6 4:7	8:6 8:12	9:1 9:9	8:2 9:3	
35.....	F	27	R L	14:12 15	6:12 7:1	5:13 12:12 5:14 13:	8:10 8:12	8:14 9:2	2:9 4:3	2:9 4:3	9: 9:	9:8 9:12	5:6 8:3	Parents favored right hand.
36.....	M	28	R L	13:3 13:7	7:2 7:7	5:11 12: 5:13 12:4	7:12 7:14	8:2 8:5	4:8 5:6	4:8 5:6	8:5 8:7	9:7 9:10 14:1	13:5 14:1	Parents and teachers tried to teach use of right hand.
37.....	F	34	R L	14:2 14:5	6:12 7:1	5:12 12:3 5:14 12:7	6:12 6:14	7: 7:3	3:7 4:5	3:7 4:5	8:13 9:1	9:5 9:11	5:7 6:9	

38.....	F	28	R	14:10	6:14	5:9	12:10	7:4	7:7	2.6	9.2	9.8	4.1
			L	14:13	7:2	5:12	12:15	7:8	7:12	3.3	9.5	9:13	5.4
39.....	M	32	R	14:8	8:1	6:	12:12	6:4	6:7	3.	8:11	9.8	9.4
			L	14:9	8:7	6:2	13:	6:6	6:10	3.9	9:	9:15	10.4
40.....	F	39	R	14:7	7:	5:8	12:10	6:3	6:7	4.	8:10	9.4	7.2
			L	14:11	7:4	5:10	12:12	6:5	6:10	5.	8:14	9:10	8.5

List No. 3—Transferred Individuals.

Number.	Sex.	Age.	Hand.	Ulna-plus.	Palm.	Wrist.	Humerus.	Forearm Relaxed.	Forearm Contracted.	% of Swell (Forearm)	Arm Relaxed.	Arm Contracted	% of Swell (Arm).	
1.....	M	23	R 13:3 L 13:8	7: 7:2	5:10 12:3 5:12 12:4	8:	8:5	3:9	7:8	8:8	13:3	7:6	8:4	Transferred to right by interference of parents and teachers.
2.....	M	22	R 13:8 L 13:4	7: 6:12	5:12 12:10 5:8 12:12	8:	8:3	2:3	8:4	9:2	10:6	8:4	9:2	Transferred to left by broken right humerus at 10 years.
3.....	F	16	R 12:10 L 12:14	6:7 6:7	5:7 11:6 5:8 11:8	7:8	7:11	2:5	7:2	7:7	4:4	7:6	7:12	Transferred to right in writing by teacher of primary school.
4.....	M	13	R 12:2 L 12:4	6:9 6:11	5:1 11: 5:4 11:4	8:	8:5	3:9	7:2	7:12	8:8	7:2	7:9	Left hand tied by parents to force use of right. Stammerer since starting to school.
5.....	M	13	R 12:4 L 12:5	7: 7:2	5:8 11: 5:12 11:2	7:8	7:11	3:4	7:3	7:12	7:8	7:5	7:12	Transferred to right by broken left humerus at 8 years.
6.....	F	11	R 10:14 L 10:14	5:8 5:11	4:8 9:10 4:11 9:12	6:	6:3	3:1	5:9	6:2	10:1	5:9	6:2	Transferred to right by broken left ulna at 9 years.
7.....	M	12	R 12:14 L 13:	6:6 6:8	5:4 11:10 5:6 11:12	7:4	7:8	3:4	7:4	7:12	6:9	7:5	7:12	Wore mitten on left hand in childhood to force transfer to right hand.
8.....	M	20	R 14:14 L 15:	8: 8:4	6:4 14: 6:10 14:2	9:1	9:6	3:4	9:3	10:4	11:6	9:1	10:	Mother tied left hand to force transfer to right. Stammerer.
9.....	M	14	R 12: L 12:4	7:3 7:3	5:8 11: 5:8 10:12	7:8	7:12	3:3	7:4	7:14	8:6	7:2	7:12	Transferred to left by compound fracture of bones of right forearm at 9 years. Stammerer since.
10.....	M	16	R 12:6 L 12:4	6:10 6:8	5:4 11: 5:2 11:	8:	8:4	3:1	7:2	7:12	8:8	7:2	7:8	Transferred to left by broken right forefinger at 9 years.
11.....	M	20	R 15:1 L 15:5	8:3 8:6	6:13 13:9 7: 13:14	10:9	11:	4:1	9:1	10:13	13:1	9:6	10:6	Transferred to right by interference of parents and teachers.

12.....	F	19	R	14:4 11:6	7:4 7:9	6:1 6:2	13:4 13:2	9:8 9:7	9:13 9:11	3:3 2:6	9:7 9:5	10: 9:12	6: 4:7	Transferred to right by parental interference.
13.....	M	22	R	15:8 15:9	8:11 8:12	6:12 6:12	13:8 13:12	10:6 10:6	10:12 10:10	3:6 2:4	11:8 11:12	12:9 13:11	9:2 8:	Transferred to right by parents and teachers. Stammer since 7 years of age.
14.....	M	19	R	15:2 15:4	8: 8:3	6:8 6:9	13:5 13:6	9:12 9:10	10:3 10:6	4:5 7:8	10:9 10:8	11:12 11:10	11:2 10:7	Punished by parents for using left hand. Stammer for 12 years.
15.....	M	45	R	15:9 15:6	8:8 8:	6:14 6:12	13:14 13:8	10: 10:2	10:5 10:9	3:1 4:3	12:1 12:4	13:3 13:10	9:3 11:2	Transferred to left in early years. Cause unknown.
16.....	M	24	R	16:10 16:12	9:2 9:3	7:4 7:6	14:12 14:13	11:1 11:	11:9 11:7	4:5 4:	12:4 12:1	13:7 13:1	9:7 8:3	Transferred to right by parental interference in childhood. Stammer for 16 years.
17.....	M	9	R	16: 10:2	5:10 5:14	5: 5:1	8:9 8:13	6:14 7:	7:3 7:4	4:5 3:6	6:8 6:9	7:2 7:2	9:6 8:6	Transferred to right by parental interference. Stammer.
18.....	F	19	R	14:2 14:	6:14 6:11	5:7 5:6	13:4 13:1	8:6 8:8	8:11 8:15	3:7 5:1	8:12 8:14	9:6 9:11	7:1 9:2	Cause of transfer to left hand unknown. Thought she was born left handed.
19.....	M	21	R	16:2 16:4	8:8 8:10	6:13 6:15	14:11 14:	11: 11:4	11:7 3:4	3:7 3:4	12:2 12:	13:6 13:2	10:3 9:4	Parents forced use of right hand. Stammered several years.
20.....	M	22	R	15:1 15:3	8:2 8:2	6:8 6:9	14:1 14:6	10:3 10:1	10:9 10:6	3:7 3:1	11:4 11:1	12:8 12:3	11:1 10:2	Left wrist broken at 11 years. Changed writing hand then.
21.....	M	7	R	11:6 11:3	6:10 6:8	5:6 5:4	9:15 9:11	7:10 7:10	7:14 7:15	3:3 4:1	8:4 7:12	8:10 8:4	4:5 6:5	Transferred to left by broken right collar bone at 4 years.
22.....	M	9	R	10:13 11:1	6: 6:2	5:2 5:4	9:15 10:	6:12 7:	7: 7:4	3:7 3:6	6:10 6:12	7:3 7:4	8:5 7:4	Transferred by parents. Stammer.
23.....	M	13	R	14:13 14:14	8:2 8:6	6:7 6:8	13:4 13:4	6:1 6:2	6:6 6:4	5:2 4:1	8:7 8:7	9:3 9:	8:9 6:7	Transferred to right by parents and teachers.
24.....	F	8	R	9:4 9:2	5:6 5:6	4:8 4:6	8:5 8:2	6:10 6:8	6:13 6:12	2:8 3:8	6:4 6:4	6:11 6:13	7: 9:	Transferred to left by broken right wrist at 6 years.
25.....	M	16	R	13:5 13:1	7:14 7:12	6:12 6:8	12:4 12:3	9: 9:3	9:5 9:9	3:5 4:1	9:1 9:4	9:12 10:2	7:6 9:5	Cause of transfer to left unknown. Stammered in early school.
26.....	F	12	R	13:3 13:6	6:6 6:9	5:8 5:10	12: 12:3	7:9 7:10	7:12 7:12	2:5 1:6	7:8 7:10	7:13 7:15	5:8 4:1	Transferred to right by teacher's interference at 6 years.

List No. 3—Transferred Individuals—Continued.

Number.	Sex.	Age.	Hand.	Una-plus.	Palm.	Wrist.	Humerus.	Forearm Relaxed.	Forearm Contracted.	% of Swell (Forearm)	Arm Relaxed.	Arm Contracted.	% of Swell (Arm).	
27.....	M	8	R 11:10 L 11:13	5:15 6:	5:1 5:1	10:11 10:12	7:1 7:3	7:5 7:8	4:5 4:3	6:3 6:5	6:11 6:13	8:1 7:9	Transferred to right by parental interference. Beginning to stammer.	
28.....	M	9	R 11: L 11:2	6:4 6:2	5:2 5:3	10:6 10:8	8: 8:2	8:4 8:5	3:1 2:3	7:10 7:11	8: 8:2	4:9 5:7	Transferred to right by writing teacher. Stammerer.	
29.....	F	9	R 10:15 L 11:	5:13 5:14	4:15 5:	10:3 10:3	6:15 7:2	7:2 7:4	2:7 1:8	6:7 6:8	7: 6:15	8:9 6:7	Transferred to right by parents and teachers.	
30.....	F	13	R 11:11 L 11:9	6:7 6:4	5:6 5:3	11:2 11:	7:6 7:4	7:9 7:9	2:5 4:3	7:6 7:2	7:14 7:12	6:8 8:8	Transferred to left by injury to right elbow at 4 years.	
31.....	M	7	R 11:4 L 11:6	6:1 6:4	5:3 5:4	10:3 10:5	7:3 7:3	7:7 7:6	3:5 2:6	7:1 7:	7:8 5:4	6:2 5:4	Transferred to right by parents and teachers. Stammerer.	
32.....	F	10	R 11:12 L 11:11	6:4 6:3	5:6 5:7	10:15 10:11	7:11 7:11	7:14 8:	2:4 4:1	7:14 7:12	8:5 8:4	5:6 6:5	Transferred to left by dislocated right shoulder at 6 years.	
33.....	F	12	R 11:12 L 11:5	6:4 6:2	5: 5:	11:2 10:15	7:3 6:14	7:6 7:3	2:6 4:5	7:9 7:5	8:2 7:13	5:6 6:8	Transferred to left in writing by loss of right forefinger at 9 years.	
34.....	F	12	R 13:12 L 13:15	6:10 6:14	5:8 5:9	12: 12:4	7:14 7:15	8:2 8:2	1:6 2:4	7: 7:	7:8 7:1	7:1 7:1	Transferred to right by parents and teachers.	
35.....	F	8	R 11:14 L 11:12	6:10 6:10	5:8 5:7	10:15 10:13	8: 7:13	8:3 8:2	2:3 4:	8:2 8:11	6:2 6:9	6:2 6:9	Transferred to left by broken right thumb at 4 years.	
36.....	F	6	R 10:10 L 10:6	6:3 6:	5:2 4:14	9:10 9:10	7:3 6:14	7:5 7:1	1:7 2:7	7: 6:12	7:8 6:5	7:1 6:5	Transferred to left. Cause unknown and transfer itself unknown until measures revealed the same.	
37.....	F	7	R 10:3 L 10:5	5:10 5:13	4:11 4:12	9:4 9:6	7:6 7:6	7:8 7:8	1:7 1:7	7: 6:14	7:1 6:4	6:4 6:4	Transferred to right by parents.	

38.....	M	22	R	16:9 L 16:6	8: 8:	6:11 6:7	14:4 14:4	10:10 10:10	10:4 11:	2.5 3.5	11:8 12:	12:8 13:4	8.7 10.4	First and second fingers of right hand lost at 13 years. Writes with left hand.
39.....	F	19	R	14: L 13:12	6:6 6:5	5:4 5:4	12:6 12:3	9: 9:8	9:5 9:12	3.5 2.6	10: 9:14	10:8 10:4	5. 3.8	Double transfer. Transferred to left by injury and operation on right elbow at 6 years. Re-transfer gradually established after a few years.
40.....	F	20	R	14:13 L 14:14	6:14 7:	5:12 5:13	13:3 13:2	8:4 8:2	8:9 8:6	3.8 3.1	8:1 8:	8:8 8:6	5.4 4.7	Transferred by parents and teachers.
41.....	F	17	R	14: L 14:2	7: 7:2	5:12 5:14	13:3 13:5	7:12 7:14	8: 8:1	3.2 2.4	7:4 7:5	7:12 7:12	6.9 6.	Transferred to right by teachers. Stammered since 8 years of age.
42.....	M	29	R	13:7 L 13:13	6:9 6:12	5:8 5:9	11:14 12:2	8:9 8:6	8:15 8:10	4.4 3.	8:12 8:7	9:15 9:8	13.6 12.6	Transferred to right by rigid discipline of parents and teachers. Stammered for 20 years.
43.....	M	28	R	13: L 13:8	6:6 6:9	5:6 5:7	12: 12:1	7:9 7:6	7:13 7:9	3.3 2.5	8:4 8:	9: 8:10	9.1 7.8	Transferred to right by parents in childhood. Stammerer.
44.....	F	20	R	13:3 L 13:4	6:11 6:13	5:10 5:12	12: 12:1	7:12 7:12	8:2 8:	4.8 3.1	8:4 8:4	8:10 8:12	4.5 6.1	Transferred to right in childhood by writing teacher.
45.....	M	31	R	14:11 L 15:2	7:6 8:	6:2 6:7	12:10 13:	9:12 9:5	10:2 9:9	3.8 2.7	10: 9:14	11:4 10:15	12.5 10.8	Transferred to right by parents and teachers.
46.....	F	40	R	14: L 14:12	7:4 7:5	6: 6:	12:4 12:7	9: 9:	9:6 9:5	4.2 3.5	9:8 9:5	10:10 10:6	11.8 11.4	Transferred to right in childhood by parents. Stammered for several years.
47.....	M	46	R	16:8 L 16:4	8:12 8:8	7:4 7:	14:9 14:3	11:12 11:14	12:3 12:7	3.7 4.7	11:4 11:	12:4 12:4	8.9 11.4	Transferred to left by right shoulder injury. Alleged ambidexter.
48.....	F	22	R	14:8 L 14:3	7:4 7:	6: 5:12	13: 12:9	8:8 8:4	8:14 8:	4.4 3.	8:12 8:4	9:2 8:12	4.3 6.1	Transferred to left in childhood by broken right clavicle. Taught to write with right hand.
49.....	F	10	R	11:3 L 11:	5:4 4:12	4:13 4:10	10: 9:9	5:13 6:2	5:15 6:5	2.1 3.1	7: 7:1	7:7 7:9	6.3 7.1	Transferred to left by broken knuckle of right hand at 7 years.
50.....	F	25	R	14:12 L 15:	7:4 7:6	6: 6:2	12:15 13:3	8:8 8:6	8:12 8:9	2.9 2.2	9:4 9:2	9:14 9:10	6.8 5.5	Trained by teacher to write with right hand. Stammered for a few years.
51.....	F	22	R	14: L 14:2	6:12 7:	5:10 5:10	12:9 12:12	8:2 8:4	8:8 8:8	4.6 3.	9: 8:8	9:10 9:	6.9 5.9	Forced by parents to use right hand.
52.....	F	16	R	13:8 L 13:8	7: 7:2	5:10 5:12	12:5 12:9	8:6 8:6	8:10 8:8	3. 1.5	8:8 8:8	9: 8:14	5.9 4.4	Transferred to right by broken left ulna at 11 years.

List No. 3—Transferred Individuals—Continued.

Number.	Sex.	Age.	Hand.	Ulna-plus.	Palm.	Wrist.	Humerus.	Forearm Relaxed.	Forearm Contracted.	% of Swell (Forearm)	Arm Relaxed.	Arm Contracted.	% of Swell (Arm).	
53.....	M	26	R 10:5 L 10:8	8:4 8:7	6:11 6:12	14:6 14:9	10:4 10:3	10:12 10:10	4:9 4:3	10:3 10:8	11:6 11:13	11:7 12:5		Trained to write with right hand. Throws with left.
54.....	M	28	R 13: L 13:5	6:14 7:1	5:7 5:10	11:1 11:5	8:8 8:10	8:13 8:14	3:7 2:9	9:12 9:10	10:9 10:6	4:3 7:8		Forced by parents and teachers to use right hand. Stammerer since 7 years old.
55.....	F	22	R 13:2 L 13:8	6:11 7:	5:5 5:8	12: 12:4	8:12 8:12	9:1 9:	3:6 2:3	9:4 9:	9:12 9:8	5:4 5:6		Wore mitten on left hand in childhood to compel use of right. Stammerer.
56.....	M	20	R 15: L 15:2	7: 7:4	6: 6:	13: 13:3	8:12 8:4	9:2 8:8	4:3 3:	8:12 8:8	9:7 9:2	7:9 7:4		Left hand tied in childhood to force use of right. Stammerer.
57.....	M	35	R 14:3 L 14:7	7:1 7:4	5:12 5:14	13:8 13:11	8:4 8:5	8:10 8:10	4:5 3:8	8:12 8:12	9:13 9:12	13:6 12:1		Trained in ambidexterity by father. Boasts of ambidexterity while stammering.
58.....	F	11	R 13: L 13:2	5:8 5:19	4:9 4:11	11:2 11:5	6:5 6:7	6:8 6:10	3: 2:9	6:4 6:4	6:11 6:11	7: 7:		Mother insisting that child use right hand, and child stammering.
59.....	M	17	R 14:6 L 14:10	6:7 6:8	5:6 5:8	13:1 13:4	8:4 8:3	8:8 8:6	3: 2:3	8:8 8:6	9: 8:12	5:9 4:5		Forced to adopt right hand in childhood. Stammerer since 7 years old.
60.....	M	37	R 14:5 L 14:8	7: 7:4	5:13 5:13	12:8 12:8	8:6 8:3	8:10 8:6	3: 2:3	8:7 8:7	9:5 9:5	10:4 10:4		Transferred to right hand by parental interference in childhood.

MEASURES OF ARM BONES OF CADAVERS AND OF UNPIECED HUMAN SKELETONS.

The number to the right of the colon in each case is the numerator of a fraction whose denominator is 16. Circumferences of bones were taken midway of the shaft.

Cadavers.

Number.	Hand.	Ulna-plus.	Length of Ulna.	Circum. of Ulna.	Weight of Ulna in Ounces.	Palm Circum.	Wrist Circum.	Length of Humerus.	Circum. of Humerus.	Weight of Humerus in oz.	Length of Radius.	Circum. of Radius.	Weight of Radius in ounces.
1	R	16:14	12:5			9:3	7:12	15:5					
	L	16:11	12:			9:	7:10	15:1					
2	R	14:12	10:5			8:5	7:1	12:15					
	L	14:8	10:1			8:	7:	12:10					
3	R	15:15	11:			9:	7:10	14:					
	L					8:10	7:8	13:12					
4	R	16:16	12:			8:8	7:1	15:4					*
	L	16:12	12:4			8:12	7:4	15:6					
5	R	15:5	10:12			8:2	7:2	14:4					†
	L	15:1	10:9			7:15	7:	14:5					
6	R	15:8	10:14			8:12	6:12	13:12					
	L	15:4	10:10			8:6	6:11	13:8					

Human Skeletons.

1	R		10:13	1:14	2:4			12:10	2:10	6:	9:14	1:11	2:1
	L		10:8	1:11	2:2			12:5	2:4	5:	9:12	1:10	2:
2	R		10:15	2:	2:2			13:2	3:	6:	10:1	1:12	1:12
	L		10:12	1:14	2:			12:10	2:12	5:	9:10	1:11	1:8
3	R		11:5	2:	2:4			12:13	2:12	5:	10:6	1:10	1:12
	L		11:1	1:14	2:			12:8	2:10	4:4	10:4	1:9	1:8
4	R		10:10	2:1	2:2			12:8	2:12	4:8	9:12	1:11	1:12
	L		10:5	2:	2:			12:3	2:8	4:	9:8	1:10	1:8
5	R		10:6	1:14	1:12			11:12	2:7	4:	9:11	1:9	1:8
	L		10:4	1:13	1:10			11:9	2:5	3:14	9:9	1:8	1:4
6	R		10:13	1:15	2:2			12:12	2:9	4:4	9:12	1:12	1:8
	L		10:9	1:14	2:			12:6	2:8	4:	9:10	1:11	1:5
7	R		9:9	1:10	1:4			11:8	2:5	3:8	8:15	1:7	1:
	L		9:10	1:12	1:8			11:12	2:6	4:	9:	1:9	1:1
8	R		10:14	1:15	1:8			13:1	3:	5:	10:2	1:13	1:3
	L		10:11	1:14	1:4			12:13	2:13	4:4	10:1	1:12	1:1
9	R		10:11	2:	2:8			12:10	2:12	5:12	10:	1:15	1:12
	L		10:8	1:13	1:12			12:6	2:11	5:4	9:12	1:14	1:8
10	R		10:9	1:12	1:8			12:10	2:10	4:4	10:	1:8	1:4
	L		10:4	1:11	1:8			12:6	2:9	4:	9:13	1:7	1:2
11	R		10:12	1:14	2:			12:9	2:9	4:8	10:	1:10	1:8
	L		10:9	1:12	1:12			12:2	2:8	4:4	9:12	1:8	1:4
12	R		10:12	1:13	1:12			13:	2:9	5:	9:15	1:12	1:8
	L		10:11	1:12	1:8			12:14	2:8	4:8	9:13	1:10	1:4

* Left handed.

† Right humerus had been fractured.

TABLE SHOWING ARM MEASURES FROM BIRTH TO DECREPIT AGE

Each of the three types of handedness is given for each 20 years. All males.

Number.	Age.	Hand.	Ulna-plus.	Palm.	Wrist.	Humerus.	Forearm Relaxed.	Forearm Contracted.	% of Swell (Forearm).	Arm Relaxed.	Arm Contracted.	% of Swell (Arm).	
1.....	0	R L	5:1 5:	3:10 3:8	3:4 3:3	4:3 4:1	4:2 4:1			4:1 4:			*
2.....	0	R L	4:10 4:12	3:6 3:8	3:1 3:2	3:13 3:14	3:14 3:15			3:12 3:13			†
3.....	20	R L	14:10 14:8	8:8 8:3	7: 6:14	13:14 13:10	10:4 10:	10:12 10:6	4.9 3.8	11:1 10:13	12:5 11:13	11.3 9.3	*
4.....	20	R L	14:6 14:9	8:4 8:8	7: 7:1	14: 14:2	10:4 10:7	10:10 10:15	3.7 4.8	11: 11:5	12:1 12:10	9.7 11.6	†
5.....	20	R L	14:11 14:13	8:6 8:10	7:2 7:4	14:1 14:3	10:6 10:5	10:14 10:12	4.8 4.2	10:15 10:13	12:3 11:14	10.2 9.8	‡
6.....	40	R L	15:5 15:1	8:12 8:5	7:5 7:2	14:4 14:3	11:2 10:14	11:12 11:5	5.6 4.	12: 11:11	13: 12:9	8.3 7.5	*
7.....	40	R L	15: 15:3	8:4 8:10	7: 7:2	14:1 14:3	10:8 10:12	11: 11:6	4.8 5.8	11:4 11:9	12:6 12:15	10. 11.9	†
8.....	40	R L	15:2 15:3	8:7 8:12	7:1 7:3	14:3 14:6	11:1 11:	11:8 11:6	4. 3.4	11:9 11:7	12:9 12:5	7.9 7.7	‡
9.....	60	R L	16: 15:13	8:14 8:5	7:4 7:	14:14 14:11	9:12 9:8	10:1 9:12	3.2 2.6	10:3 10:	10:15 10:10	7.5 6.3	*
10.....	60	R L	15:11 15:12	7:12 8:	6:15 7:	14:10 14:12	9:7 9:11	9:12 10:2	3.3 4.5	10: 10:3	10:15 11:5	9.4 11.	†
11.....	60	R L	15:12 15:13	7:13 8:4	6:15 7:2	14:7 14:9	10: 10:	10:5 10:4	3.1 2.5	10:12 10:10	11:13 11:9	9.8 8.8	‡
12.....	80	R L	13:10 13:9	7:12 7:8	6:10 6:9	12:15 12:11	9:1 8:14	9:4 9:	2.1 1.4	9:1 8:15	9:11 9:7	6.9 5.6	*
13.....	80	R L	14: 14:2	7:10 7:15	6:8 6:10	12:12 12:13	9: 9:3	9:3 9:7	2.1 2.7	9:4 9:6	9:13 10:1	6.1 7.3	†
14.....	80	R L	13:12 11:10	7:14 7:9	6:11 6:10	12:12 12:11	8:15 9:2	9:2 9:6	2.1 2.7	9: 9:1	9:8 9:11	5.6 6.9	§
15.....	101	R L	13:9 13:7	7:11 7:9	6:8 6:7	12:8 12:6	8:2 8:	8:5 8:2	2.1 1.6	8: 7:13	8:8 8:4	5.8 5.6	*
16.....	94	R L	14:8 14:9	7:12 7:15	6:13 6:14	13:9 13:10	8:10 8:13	8:13 9:1	2.2 2.8	9: 9:2	9:9 9:13	6.3 7.5	†
17.....	93	R L	13: 13:2	7:12 8:	6:13 6:15	12:3 12:6	8:14 8:12	9:2 8:15	2.8 2.1	9:2 9:1	9:11 9:8	6.2 4.8	‡

¶ Stillborn.

* Right hander.

† Left hander.

‡ Left to right transfer.

§ Right to left transfer.

Interpretation of Data.

An examination of the tabulated data reveals the fact that each of the 300 living subjects has longer bones in one arm than in the other. The cadavers, which readily lend themselves to the most rigid treatment, reveal the same thing. The arm bones of the human skeleton, measured for length, circumference, and weight, show that the bones of one arm are not only longer, but proportionately larger around and heavier, the sturdier bones being in the right arms of right handers, and in the left arms of left handers. Finally, the condensed table for ages shows that this difference in bone equipment of the arms is just as evident at birth as in adult life, and just as marked in youth as in decrepit age. We are not only right or left handed, but we are born right or left handed, and the arms themselves bear the evidence. This, then, is the primal fact revealed by the study; namely, the human being is born with a major and a minor arm; and we have the following

MEASURES FOR DETERMINING BORN HANDEDNESS:

(The major arm excels the minor arm in these measures.)

1. The length of the ulna-plus.
2. The palm circumference.
3. The wrist circumference.
4. The length of the humerus.

A little study of the data will show that these measures, not unlike any measures known to science, must be applied with circumspection. Bone injury and bone diseases are not uncommon, and either injury or disease may enlarge or shorten or stunt the growth of a bone. Any one who attempts to diagnose handedness, therefore, must be on the lookout for the signs and the history of arm and shoulder deformities. Thus in record 76, on page 19 we find the right humerus shorter than the left, though the measures for the ulna-plus, the palm, and the wrist, all favor the right side. With three witnesses against one it is reasonable to suspect injury. The history of the case showed that the subject had

suffered a broken right humerus ten years before, and the surgeon who had "set the bone" attributed the shortening of the humerus to an "overriding fracture." Number 12, on page 35 shows the same thing with the left arm. Number 9 on page 34 shows a short right ulna-plus, with the palm measures equal, the wrist measures favoring neither side, and the larger humerus on the right. This case could readily be misinterpreted by a hasty or careless diagnostician. An examination of the arms revealed enlargements of both bones of the right forearm with no evidence of injury to the left arm. This suggested a shortening of the right forearm from bone injury. Further evidence was found in the fact that the right forearm muscle was both small and weak as compared with the left, suggesting disuse of the right forearm. Finally the history of the case revealed a compound fracture of the bones of the right forearm six years before; and so the chain of evidence showing the child a born right hander was complete. Such cases are often met, as may be seen by the notes accompanying the tabulated measures, and the diagnostician must be ready in their interpretation.

The first question which this investigation set out to answer, namely: "How can we determine, *de novo*, whether a child is born right or left handed?" has found its answer in the bone measures of the arms; and we may now turn to the second question; namely, "How can we distinguish born handedness from acquired handedness?"

In record number 64, on page 19, we find that the bone measures favor the left side; that is, the subject is a born left hander; but we find the muscle swells favoring the right arm. Now muscle grows with use, and the larger percentage of muscle swell reveals the arm that is most in use; that is, the larger percentage of muscle swell reveals the adopted arm. This subject is a born left hander, but in some way he has acquired a dominant use of his right hand. In the note column we find the history that explains the case; namely, the parents, following tradition, have succeeded in transferring the child to the right hand.

Record number 76, on page 19, reveals a transfer from right to left. The bone measures, excepting the measure of the right humerus as we have already noted for this individual, reveal born right handedness, while the muscle swells show that she is using the left arm the more freely. The accompanying note in the explanatory note column gives the history that reveals the cause of the transfer.

The use of a hand and arm is thus revealed by the muscle swells, and the adopted arm sooner or later comes to have the higher percentage of muscle swell. Our answer to the second question; namely, "How can we distinguish born handedness from acquired handedness?" is therefore at hand.

BORN HANDEDNESS IS REVEALED BY THE MEASURES OF THE BONES OF THE ARM, THE MAJOR ARM HAVING THE LARGER BONES; ADOPTED HANDEDNESS IS SHOWN BY THE MUSCLE SWELL, THE ADOPTED, OR PREFERRED, ARM HAVING THE HIGHER PERCENTAGE OF MUSCLE SWELL.

A little study of the data again will show that the muscle swell, too, must be judged with circumspection if the problem of born and acquired handedness is to be safely settled. Record number 6, on page 34, shows an individual born left handed, since three witnesses favor the left, though one, the ulna-plus, is neutral; but the forearm muscle swell favors the right side, and the arm muscle swell is neutral. An examination of the arms revealed an enlargement of the left ulna just above the wrist, affecting also the wrist measure; and the left hand showed an outward deflection from the line of the arm. We hardly need the history of the case to make it clear that this subject has just passed over the line of transfer, due to a broken left ulna of short time standing, so short time indeed that the forearm muscles of the right arm are but little stronger than those of the left, and the two arm muscles are just on the neutral line. The history given in the explanatory note, however, corroborates the evidence.

Record 36, on page 36, shows a right-to-left transfer. The parents were not aware that the child had ever been transferred, and the cause of the transference is not definitely known. The history of the case revealed that the child had fallen down a flight of porch steps at three years of age and injured the right shoulder. The attending physician had the right arm carried in a sling for a few weeks, and soon afterwards the child was "found to be left handed." There is little doubt that the child adopted the left hand while the right arm was in the sling; and then with no attention given to the normal handedness when the arm was removed from the sling, the child continued to use the left hand and arm.

Turning now to the explanatory note column of the tabula, the reader may note that a record is there given of each case of stammering. (The term "stammering" is here used to include both stammering and stuttering, since the two terms are absolutely synonymous in ordinary use. Stammering, technically speaking, is imperfect enunciation due to lack of control over the muscles of articulation, the sounds being properly vocalized; while stuttering is defective vocalization, or defective voicing of sounds. A stammerer is likely to have trouble in enunciating initial syllables beginning with b, p, d, or t, but the stutterer repeats the syllables.) Since the prevalence of stammering is a matter to be determined by mass data, it may best be handled with the table of summaries.

The table showing the summaries of measures of the 20,000 pairs of arms is given on page 41. In the first column of the table is indicated the number of individuals whose measures are included in the summaries. In the second column is given the number of those (included in the first column) who were found to be born right handed, and in the third column the number found to be born left handed, according to the scale of measures already explained. In the fourth and compound column is recorded the number of transfers classified in groups according to the type of hand-

edness shown. In the fifth column (also compound) is given the number of stammerers, also classified in groups according to handedness. At the foot of the table is given the proportionate numbers of males and females born right handed and left handed, the total number of stammerers who began to stammer under eight years of age, and the proportion of males and females among the stammerers.

The summaries of the first three columns show that out of 20,000 persons whose arms were measured, 19,207 are born right handers, and 793 are born left handers; that is,

96% OF THE HUMAN RACE ARE RIGHT HANDED BORN, AND *4% ARE LEFT HANDED BORN.

The summaries further show that out of 19,207 born right handers, 9,502 are males and 9,705 are females, while out of 793 born left handers 498 are males and 295 are females; that is, born left handedness is far more common among males, the ratio being about 5 males to 3 females. [Ballard estimates about 2 to 1 in favor of males, but in his study he made no distinction between born handedness and acquired handedness.]

The transfer column shows that out of 20,000 persons, 815 (4%) are transferred. Six hundred one of these (74% of all transfers) are transferred by purposive interference, and 214 (26% of all transfers) are transferred by accident. We find no case of purposive transference from the right to the left hand [Tradition favors the right hand, and left in tradition means unlucky], but out of 793 born left handers we find that 601 (76% of all born left handers) are transferred to the right hand by purposive interference.

We also find that out of 19,207 born right handers, 203 (about 1%) are transferred to the left hand by accident, and out of 793 born left handers, 11 (about 1%) are transferred to the right by accident. Restating the facts of transfer,

* The literature on handedness is full of estimates of the proportion of right and left handers, running from 3% to 6%; but since none of the authors distinguish between born handedness and acquired handedness there is little value in making specific comparisons.

we have the following *approximate percentages:

4% OF THE RACE ARE TRANSFERRED TO THE MINOR ARM. (1 out of about 25 persons.)

1% OF ALL BORN RIGHT HANDERS ARE TRANSFERRED TO THE LEFT HAND BY ACCIDENT.

1% OF ALL BORN LEFT HANDERS ARE TRANSFERRED TO THE RIGHT HAND BY ACCIDENT.

76% OF ALL BORN LEFT HANDERS ARE TRANSFERRED TO THE RIGHT HAND BY PURPOSIVE INTERFERENCE.

77% (over three-fourths) OF ALL BORN LEFT HANDERS ARE TRANSFERRED TO THE RIGHT HAND.

The stammerer column shows that out of 20,000 persons, 390, or nearly 2%, are stammerers or are **reported to have been stammerers earlier in life [Ballard estimates not over 2% among normal children, and 17% among left handers who write with the right hand]; and that 340, or 87%, of these are males, and 51, or 13%, are females. (Medical writers commonly refer to the high percentage of male stammerers; and the Wisconsin State Department of Education reports over 85%.—Educational News Bulletin, Wisconsin State Department of Education, Madison, February 1, 1917, p. 2.)

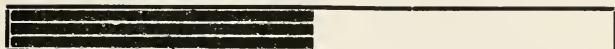
Out of 19,004 born right handers who have adopted the right hand, 120 (about $\frac{1}{2}$ of 1%) are stammerers; while out of 181 born left handers who have adopted the left hand, 18 (about 1%) are stammerers. Out of 203 right-to-left transfers, 33 (16%) are stammerers, while out of 612 left-to-right transfers, 219 (36%) are stammerers. (Ballard found 17% among his "dextro-sinistrals."—*Jour. of Exp. Ped.*, Vol. 1, No. 4, p. 309.) Finally we note that out of the 390 stammerers, 203 (52%) are transfers; and that 339 of the 390, or 87% (and 168, or 83%, of the 203 transfers) are reported to have begun to stammer under 8 years of age. [It is safe

* The standard deviation of 7.8% makes rough estimates in place here.

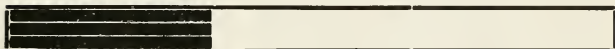
** The reports of earlier stammering are believed to be quite reliable, since it is characteristic of the recovered stammerer that he well remembers his former condition. The readiness to conceal the defect is not hard to offset if the subject is sympathetically approached. There were 79 cases of earlier stammering in the total number of 390 cases, and these were carefully questioned for symptoms before accepted as recovered stammerers.

to assume that the number of reported cases is somewhat low, since no case was included in the list if the starting time was apparently doubtful. The Wisconsin State Board of Education reports 70% of stammering beginning at 6 years or under. See Educational News Bulletin, Madison, Feb. 1, 1917, p. 2.]

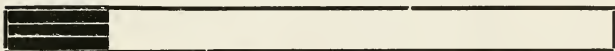
One-half of all stammerers are transfers.



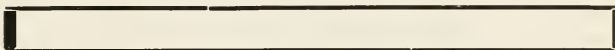
One-third of all left-to-right transfers are stammerers.



One-sixth of all right-to-left transfers are stammerers.



Less than 1% (per cent) of pure handed individuals are stammerers.



RELATION OF HANDEDNESS AND STAMMERING.

Restating the *facts of stammering, we have the following:

One-third of left-to-right transfers are stammerers.

One-sixth of right-to-left transfers are stammerers.

About 1% of pure left handers are stammerers.

Less than 1% of pure right handers are stammerers.

One-half of all stammerers are transfers, and four-fifths of all stammering begins before the eighth birthday.

About seven-eighths of all stammerers are males.

Several questions at once arise; namely, (1) How is the high percentage of stammerers among transfers, especially the left-to-right transfers, to be accounted for? (2) Why is the proportion of male stammerers so high, even though we allow for the fact that the ratio of born left handed males to born left handed females is about five to three? and (3) Why does stammering commonly begin during the early years? Any serious attempt to answer these questions to-day must resort to one or both of two methods; namely, (1) speculation in the field of brain psychology, and (2) experimental treatment to derive concrete evidence. We may well combine the two methods.

SPECULATIVE TREATMENT of the CAUSAL RELATION BETWEEN HAND TRANSFER- ENCE AND STAMMERING.

The fundamental fact of handedness, in so far as we can yet unravel it, is the fact of congenital cerebral asymmetry. The present day knowledge of brain psychology is very incomplete, but a speculative treatment of our problem in terms of the best theory that physiological psychology has to offer will be at least better than no attempt at explanation at all. It will at least try the theory; and theories are established or broken down through use.

We may take as our starting point, the prevailing physi-

* Since the standard deviation on the average number of stammerers per thousand individuals is 12.7%, the proportions are given as rough fractions rather than as definite percentages.

ological theory (1) that there are *four highly specialized cortical centers involved in the speech of the normal adult; namely, two sensory—the auditory and the visual, and two motor—the vocal and the writing (graphic word) centers; (2) that all four of these centers are normally located in one (hence called superior) hemisphere of the brain; namely, the left hemisphere in the **born right handed individual, and the right hemisphere in the **born left handed individual; and (3) that though the muscles of the vocal organs are anatomically connected with each hemisphere, they are functionally connected ^{with} only one; and in so far as the hand is an organ of speech, at least, it shares the same asymmetry.

Since the child hears words freely before he speaks or sees or writes them; since he speaks them freely before he sees them, and sees them freely before he writes them freely, we may reasonably assume that the graphic word, or writing, center is the last to be called into function. We may also assume that the writing center is called into function whenever the child begins to write or scribble, and this is quite certain to be before he is 8 years of age. Suppose a born left handed child is learning to write. If he is allowed to write with the left hand, then we may assume that the writing center is developed in the right hemisphere—the hemisphere in which the auditory, the vocal, and the visual centers are already located. This unified placement of word centers we may consider normal according to our physiological theory. But suppose the born left handed child is required to write with his right hand. Then we may assume that the writing center is developed in the left (the inferior) hemisphere. What will happen? We may speculate that any one of three things will occur; namely, (1) the lack of unity resulting from the location of three of the word centers in one hemisphere and one in the other, will bring functional disharmony due to the fact that the neural currents

* If we take the position with Collier and others (see "Brain," Part CXXIV, Vol. XXXI, 1908, p. 540) that the existence of separate auditory and visual speech centers rests upon the "slenderest facts," it will change our speculation in no significant respect; and few will go so far today as to agree with Marie that there is only one speech center (see Sem. Med., 23 mai, 1906, p. 241.)

** The addition of this word is suggested by this study.

are ill-timed or even conflicting, thus giving rise to speech checking, speech hesitation, or stammering; (2) the free use of the right hand in writing may firmly seat the writing center in the right hemisphere and this may be followed by the transference (the "dragging over" theory) of the three word centers from the left to the right hemisphere, thus giving rise to extreme functional disturbance, for a time at least, that may initiate stammering through lack of co-ordination; (3) since the child may have attempted some left hand writing before formal writing work began, indeed may even continue the same when left free to himself, two writing centers or even two sets of speech centers, one in either hemisphere, may be developed (theory of ambidexterity advocates) which in turn could seriously interfere with neural co-ordinations and lead to stammering. In any case we must assume that there is an intimate functional connection among the four word centers, such that whenever the last developed center (the writing center) is functioning, all the word centers are likely to function; and any interference with this functional unity may result in turning the neural currents into wrong or even conflicting channels, thus giving rise to checks, to hesitation, to stammering. The fact that no lesion has so far been discovered, leaves us with only the function to speculate upon; but any one of the above speculations gives us a possible explanation.

We may further speculate that one child is more readily set to stammering than another for the reason that the intimate functional connection of the four word centers is more readily disturbed in one than in another. The general nervous stability is undoubtedly a determining factor. A child dominantly vocomotor, or linguistic, may be more difficult to unsettle than other types, and we may speculate that it is for this reason that stammering is less common among females.

When we come to speculate with the fact that stammering commonly begins before the age of 8 years, we may assume that since this is the period when the language centers are being developed, it is also the time when the functional unity of these centers is the least stable. The trans-

fers are the likely stammerers, probably for the reason that the unity of language centers is so likely to be disturbed. We may assume (1) that 36% of the left-to-right transfers stammer for the reason that this transference is commonly accomplished under exasperating conditions, such as nagging, threatening, hand tying, wearing of mittens, and so on to the limit of tradition and human ingenuity, that in themselves superinduce morbid sensitivity and nervous instability; and (2) that 16% of the right-to-left transfers stammer because they are transferred by injuries and treatment that are themselves serious attacks on neural stability, though commonly of shorter duration than the nagging era of left-to-right shifting. We may assume that the percentage of stammering is higher among pure left handers than among pure right handers for the reason that so few left handers escape traditional interference; and finally we may believe that there are causes other than hand transference operating in the direction of stammering.

**EXPERIMENTAL TREATMENT
of the
CAUSAL RELATION BETWEEN HAND TRANSFER-
ENCE AND STAMMERING.**

Having concluded the speculative treatment of the causes of stammering, we may now return to experimental means to discover whether or not the main principle assumed in the speculation is sound. We may state our problem as follows: **Does writing with the minor hand invite stammering?**

In the effort to get definite data on this problem, two subjects were chosen who were known to be near the stammering line, one just recovering from stammering, the other just beginning to stammer, and subjected to composition writing tests. The recovering stammerer was required to write with the minor arm and the stammering subject with the major arm. The first subject was a 14-year-old boy whose arm measures are recorded under number 5, page 30. This boy was apparently in ordinary health, with a systolic blood pressure (auscultatory method, sitting posture) commonly ranging from 115 to 120, a pulse pressure of 32, usually quite nervous (esthesiometer reading from 19 to 23 on back of left hand), but with no physical defect revealed by physical examination excepting a *constricted and adherent prepuce. He was a born left hander and his parents had tried to force the use of the right hand, but gave up when the boy reached his 12th year still dominantly left. He had stammered for several years, but had shown no signs of same for a few months previous to the tests. The second subject was the 8-year-old boy whose record is number 27, on page 36. This child passed a fair physical examination. His hearing range was short, and he had had adenoids removed two years before. His nerves were quite unstable (esthesiometer reading 15 to 18) and he carried an undescended testicle. He was a left-to-right transfer, due to parental interference, and he was beginning to stammer.

The 14-year-old recovering stammerer was set to writing compositions on various subjects of interest to himself,

* This defect is significantly common in stammerers.

the writing being done with the minor (right) hand. (He had been required to use this hand in writing during the years he had stammered.) He was required to write for three twenty-minute periods daily, taking up a new subject as soon as he lacked thought on the one in hand, and he was stopped at the end of each twenty-minute period and asked to tell what he had written. If no signs of stammering appeared he was excused from speaking and set to writing again. At the end of the eighth twenty-minute period (second period of the third day) stammering was clearly evident and the subject was excused from further writing. In order to try the counter effect, the boy was set to writing with his left (minor) hand, for one twenty-minute period a day until the results could be determined. The stammer was evident for a period of eleven days, then disappeared with occasional lapses for a period of five weeks. During the last four weeks the formal left hand writing tasks were discontinued but the left hand was used exclusively in whatever writing was done. At the end of seven weeks from the time of the first experiment, the boy was given another trial at right hand writing, under the same conditions as before, and the stammer returned at the end of the fifth twenty-minute period. Recourse to left hand writing was again taken, and the stammer continued for seventeen days with eight weeks of occasional lapses, then the formal writing was ceased but the left hand was used exclusively in writing and is in use at the time of the present writing, six months having elapsed since the stammer disappeared.

The eight-year-old, left-to-right transfer, who was just beginning to stammer, was using his right hand in whatever writing he had to do, including a fifteen-minute daily writing lesson in school. The parents and the teacher consented to allow the boy to use his left (major) hand in his writing, in order to see what the result would be in terms of stammering. The boy was then set to writing formal writing lessons for two fifteen-minute periods daily, one in the forenoon and the other in the afternoon. The writing was done with the left (major) hand, and the subject was ready to co-operate by doing all his writing with the same hand. After two weeks, daily compositions on topics of interest to the boy were substituted for the formal writing,

in order to involve the speech centers fully. The compositions were written in three ten-minute periods, with five-minute intermissions for telling aloud what he had written. The boy was a slow and laborious writer and usually whispered the words as he wrote them (*Conradi found that stammerers are as a rule backward in school work, but suggests that this is probably due to psychic depression brought about by mockery. We have no evidence so far that shows the stammerer below average mentally, though we do find him below in school work involving speech).

His speech during the five-minute "telling intermissions" was closely watched. Not until the twenty-second day of composition writing could it be unmistakably seen that the stammer was disappearing. At the end of forty-seven days of composition writing the boy carried on conversation without hesitation, and the composition writing was discontinued, though the writing in school and elsewhere was done with the left hand. After a ten-day respite, during which time the boy reported no serious lapse of speech, it was arranged to try writing with the right (minor) hand. The three ten-minute composition periods, with five-minute "telling intermissions" were used as before, and the school writing was discontinued by two weeks of vacation. On the third day of the composition writing with the right (minor) hand, evidence of stammering reappeared; and on the fifth day the child was unable to handle words beginning with the letter "b." The writing was then resumed with the left (major) hand and carried on as before for twenty-seven days before the stammer was lost.

These two bits of experimental evidence, insufficient in themselves to settle questions that arise, but rather pointing the way for further study, are unmistakable evidence that there is an intimate relation between minor hand writing and stammering. They seem to give depth of meaning to the experimental evidence already produced, and they strengthen faith in the fundamental theories of brain psychology. We are driven to the conclusion at least that the tradition that would force all left handed children to write with the right hand is a tradition as dangerous as it is ignorant of possible consequences.

PART II.

**SHOULD THE LEFT HANDED CHILD BE TRAINED
TO ADOPT THE RIGHT HAND?**

PROBLEM—SHOULD THE LEFT HANDED CHILD BE TRAINED TO ADOPT THE RIGHT HAND?

Material and Handling.

The material for this part of the study consists of the measures of hand and arm skill of 1125 individuals of whom one-third, or 375, were pure right handers (born right and adopted right), one-third, or 375, pure left handers (born left and adopted left) and one-third, or 375, transfers (part right-to-left, and part left-to-right). Subjects were chosen to reveal the hand skill of young children, of youth, and of adults of both sexes. The individuals represent purely chance selection within the age limits specified.

Three tests of hand and arm skill were used; namely,

1. The shot tube test.
2. The peg board test.
3. The tapping rate test.

The shot tube test was chosen for a test chiefly of hand skill; the tapping rate test, a test chiefly of arm ability, and the peg board test, a test of combined hand and arm skill in about equal proportion. All three of the tests give scores large enough to show comparative skill.

DESCRIPTION OF SKILL TESTS.

1. Shot Tube Test.

The shot tube test is a test to determine the number of seconds required for the subject to pick up with the fingers 25 quarter-inch steel balls, one at a time, and drop them into a vertical tube $6\frac{1}{2}$ inches high and with a mouth three-eighths of an inch in diameter. Thirty-five of the steel balls, called "shot" for convenience, were placed in a wooden dish made with a hopper bottom so that the shot could always be readily located. The dish containing the shot was placed just to the right of the loading tube when the loading was to be done with the right hand, and similarly to the left of the tube for the left hand. Each subject was allowed three



THE SHOT TUBE TEST

trials with each hand before the test began, and he was encouraged to load as fast as possible. When ready for the test, the subject was instructed to hold the tube firmly with one hand, and to place the other hand (hand to be tested) with the fingers at the mouth of the tube as if preparing to drop a shot. A stop watch was held at his ear with instructions to begin picking and loading the instant the stop watch was clicked to start, and to continue until the tube was filled with shot irrespective of the number dropped. The operator stopped the watch the instant the 25th ball clicked in its place in the tube.

Two series of record trials, four trials in each series, were made in the following order: First series—first trial with the major hand, second and third trials with the minor hand, fourth trial with the major hand. After a pause of two minutes, the second series was given—first trial with the minor hand, second and third trials with the major hand, and the fourth with the minor hand. The average of the four records made with each hand was tabulated for the final record.

2. The Peg Board Test.

The peg board test is a test to determine the number of pegs the individual can place, or load, in an ordinary kindergarten peg board (Mrs. Putnam's Peg Board) in 30 seconds. The subject was seated at a table with a 100-hole peg board in front of him. The 100 pegs were contained in the pasteboard box placed just to the right of the peg board when the loading was to be done with the right hand, and in a similar position on the left when the loading was to be done with the left hand. Each subject was allowed three trials with each hand before the test began. He was instructed to load as fast as possible and to place the pegs in order in the 25 holes, beginning at the hole farthest from the peg box. When ready for the test the subject was directed to place the index finger of the loading hand over the first hole to be loaded, and to steady the peg board with the other hand. A stop watch was held at his ear with the under-

standing that the loading was to begin when the watch was clicked to start and that the loading was to continue until the watch was clicked to stop. Two series of record trials, four trials in each series, were made and recorded as already described in the shot tube test.

3. The Tapping Rate Test.

The tapping rate test used was the familiar test to determine the number of taps with a pencil that the arm is able to make in a given time. The subject was seated at a table across which was drawn a long strip of adding machine paper. She was handed a hard lead pencil about four inches long and instructed that the object was to make as many taps (dots) on the paper as possible in 30 seconds, holding the hand in one position while the operator moved the paper slowly along. (No machinery for moving or recording was used.) The operator sat to the left of the subject and moved the paper slowly from right to left when the tapping was done with the right hand, and to the right of the subject with the movement of the paper reversed when the tapping was done with the left hand. When ready for the test the operator took the stop watch in one hand and seized the end of the paper strip with the other hand. The subject was instructed to begin tapping the instant the stop watch was clicked at his ear and to continue until the paper was jerked from under his pencil at the end of the 30 seconds. One practice trial with each hand was allowed before the record trials began. Two record trials with each hand were made, the first with the major hand, the second and third with the minor hand, and the last with the major hand. The taps were counted by marking them off in fives, and the average of the two trials with each hand was tabulated for the final record.

DATA.

In the first of the following tabula (page 63) are given the measures of the hand and arm skill of seventy-five boys from 14 to 16 years of age, as shown by the shot tube test. Twenty-five of these boys were shown by brachiometer measures to be pure right handers, that, is born right handed and using right; twenty-five were pure left handers (born left and using left), and twenty-five were transfers. The tabulated record for each individual shows five facts; namely, (1) the number of the individual in the list; (2) the age—given to the nearest birthday for adults, but expressed in years and months for individuals under 25 years of age. [Age 16:2 means 16 years and 2 months]; (3) the record made by the right hand in the given test: (4) the record made by the left hand, and (5) the range of skill, or the difference between the skill records of right and left hands. [Since part of the transfers are right-to-left, and part left-to-right, their records are given in the same columns under the headings "Major" and "Minor" instead of "R" (right) and "L" (left) hands.]

In the second tabulum (page 64) are recorded the measures of hand and arm skill of seventy-five women (twenty-five of each handedness group) from 21 to 24 years of age, as shown by the peg board test. The five columns of data are given under headings the same as for the shot tube test just explained.

In the third tabulum (page 65) the measures of hand and arm skill of seventy-five girls (twenty-five of each handedness group) from 7 to 9 years of age, as shown by the tapping rate test. The five columns of data are given under headings the same as for the shot tube and peg board tests.

The column average is given at the foot of each column to show the central tendency, and the average deviation (A. D.) from the average is given to show the deviation from the central tendency.

SHOT TUBE TEST.

(Records indicate number of seconds and 10ths of seconds required to load 25 shot.)

14 to 15 Year Old Boys.

(Over 13½ and Under 15½ Years.)

Pure Right Handers.					Pure Left Handers.				Transfers.			
Number.	Age.	Right Hand.	Left Hand.	Range.	Age.	Right Hand.	Left Hand.	Range.	Age.	Major Hand.	Minor Hand.	Range.
1	16:2	39.4	44.2	4.8	16:2	35.2	30.	5.2	16:5	41.2	42.6	1.4
2	16:5	30.6	39.	8.4	15:11	41.2	38.4	2.8	14:5	47.	49.2	2.2
3	15:4	35.6	42.6	7.	15:7	42.6	39.	3.6	13:10	49.4	50.4	1.
4	16:4	35.4	41.2	5.8	15:5	45.4	40.2	5.2	16:	36.2	38.2	2.
5	15:4	34.8	40.	5.2	14:3	44.8	42.	2.8	13:9	48.6	51.2	2.6
6	15:1	38.4	44.2	5.8	15:9	40.8	35.2	5.6	16:1	36.2	38.4	2.2
7	15:8	33.8	40.	6.2	14:3	45.6	40.4	5.2	15:3	43.6	44.6	1.
8	14:8	44.2	50.2	6.	15:4	51.2	45.2	6.	15:11	38.4	39.4	1.
9	14:	44.4	51.6	7.2	14:3	43.2	40.4	2.8	15:11	39.2	41.6	2.4
10	14:9	33.4	40.2	6.8	15:	42.2	39.	3.2	16:4	33.	34.2	1.2
11	14:2	39.4	44.4	5.	16:4	36.	32.8	3.2	13:8	42.6	44.2	1.6
12	15:2	37.2	45.6	8.4	16:3	40.2	36.2	4.	16:2	33.	36.6	3.6
13	13:6	47.4	52.2	4.8	13:6	52.2	46.4	5.8	13:9	44.2	45.8	1.6
14	15:7	40.6	44.8	4.2	13:9	50.6	45.8	4.8	13:10	48.8	50.4	1.6
15	15:9	39.6	46.	6.4	13:7	52.	47.2	4.8	14:4	43.	45.4	2.4
16	14:3	46.2	50.8	4.6	14:5	46.	42.6	3.4	15:9	43.2	44.	.8
17	14:10	45.2	49.2	4.	16:2	41.8	35.8	6.	14:5	47.2	49.4	2.2
18	15:1	38.2	43.4	5.2	14:10	47.6	40.2	7.4	15:7	39.2	39.4	.2
19	13:9	43.	48.8	5.8	15:8	45.	38.8	6.2	13:7	45.6	46.4	.8
20	13:11	46.8	52.8	6.	15:3	44.2	40.2	4.	15:1	40.2	44.8	4.6
21	14:3	37.4	43.	5.6	14:7	45.6	41.	4.6	15:2	45.2	45.6	.4
22	13:8	39.6	44.2	4.6	13:10	51.4	44.2	7.2	14:11	44.8	45.6	.8
23	16:1	32.2	38.4	6.2	15:9	42.2	37.8	4.4	15:4	40.8	43.8	3.
24	15:4	38.2	44.8	6.6	14:1	48.2	42.6	5.6	15:4	40.4	41.	.6
25	14:	40.	45.2	5.2	14:7	53.2	44.8	8.4	15:10	38.6	40.	1.4
373:1 981.0 1126.8 145.8 374:6 1128.4 1006.2 122.2 376:8 1049.6 1092.2 42.6												
Av. 14:11 39.24 45.072 5.832 15: 45.136 40.248 4.888 15:1 41.984 43.688 1.70												
*A. D. 3.65 3.33 .88 3.79 3.19 1.21 3.79 3.64 .81												

*Average Deviation from the average which is shown just above in each case.

A STUDY OF HANDEDNESS

PEG BOARD.

(Records indicate number of pegs placed in 30 seconds.)

21 to 24 Year Old Women. (Over 20½ and Under 24½ Years.)

Pure Right Handers.					Pure Left Handers.				Transfers.			
Number.	Age.	Right Hand.	Left Hand.	Range.	Age.	Right Hand.	Left Hand.	Range.	Age.	Right Hand.	Left Hand.	Range.
1	22:4	38	34	4	22:11	34	38	4	22:8	33	29	4
2	21:3	34	30	4	23:2	34	40	6	20:6	30	28	2
3	22:2	40	36	4	20:11	31	35	4	20:11	34	32	2
4	24:1	42	34	8	24:3	36	40	4	21:9	33	32	1
5	23:4	36	30	6	23:9	26	39	3	23:8	32	29	3
6	22:1	36	28	8	23:4	26	30	4	23:11	34	29	5
7	23:2	32	28	4	22:11	34	40	6	24:4	34	33	1
8	20:6	36	28	8	21:9	32	36	4	22:10	33	30	3
9	21:4	34	27	7	20:9	28	33	5	22:5	33	33	0
10	22:8	34	30	4	21:6	27	34	7	20:7	32	30	2
11	20:7	32	28	4	21:8	26	34	8	21:11	28	28	0
12	21:	32	30	2	24:4	33	38	5	24:3	34	34	0
13	22:6	37	34	3	23:3	35	39	4	23:9	35	34	1
14	23:	41	35	6	22:10	30	34	4	22:5	33	32	1
14	22:2	34	30	4	23:9	32	38	6	23:9	35	34	1
16	21:2	32	26	6	22:11	34	39	5	22:4	34	34	0
17	23:3	30	25	5	23:8	33	38	5	20:10	31	30	1
18	24:4	38	34	4	22:10	33	37	4	21:8	30	28	2
19	23:1	36	28	8	21:7	29	32	3	23:7	34	32	2
20	20:8	34	31	3	22:4	30	34	4	24:	36	35	1
21	21:2	32	27	5	24:1	32	34	2	23:9	35	34	1
22	23:5	37	29	8	23:8	28	32	4	23:	33	31	2
23	23:4	36	31	5	23:2	35	39	4	22:8	33	33	0
24	24:	42	36	6	21:9	32	35	3	23:5	35	33	2
25	24:4	41	37	4	20:11	31	33	2	21:10	32	30	2
560:11 896 766 130					568:	791 901 110	566:9 826 790 36					
Av	22:5	35:84	30:64	5.2	22:9	31.64 36.04	4.4	22:7	33.04 31.60	1.44		
*A. D....	2.74	2.85	1.52			2.43 2.60 1.07			1.32 1.84	.86		

* Average Deviation from the average which is shown just above in each case.

TAPPING RATE.

Time—30 seconds.

(The records indicate the number of taps in 30 seconds.)

7 to 9 Year Old Girls (Over 6½ and Under 9½ Years.)

Number.	Pure right handers.				Pure left handers.				Transfers: 1st ten right-to-left; others left-to-right.)			
	Age.	Right Hand.	Left Hand.	Range.	Age.	Right Hand.	Left Hand.	Range.	Age.	Major Hand.	Minor Hand.	Range.
1	7:10	142	118	24	7:3	121	140	19	9:	142	134	8
2	8:	145	126	19	7:	118	138	20	7:7	135	127	8
3	6:7	129	112	17	8:3	126	145	19	9:1	126	120	6
4	7:6	139	115	24	8:3	130	150	20	7:9	136	129	7
5	8:11	151	132	19	7:6	118	137	19	8:3	142	132	10
6	8:	147	125	22	7:4	122	135	13	7:10	139	133	6
7	9:3	148	130	18	8:8	128	143	15	6:10	127	121	6
8	7:4	139	121	18	8:10	132	149	17	7:8	134	125	9
9	8:2	144	114	30	9:1	123	148	25	6:8	120	118	2
10	7:11	141	117	24	8:6	121	145	24	8:11	131	124	7
11	8:10	142	120	22	8:	120	141	21	8:5	137	129	8
12	9:5	151	140	21	7:7	117	136	19	6:8	124	122	2
13	8:4	148	121	27	7:9	118	139	21	7:3	152	128	4
14	6:9	124	110	14	9:4	129	146	17	8:2	133	122	11
15	7:2	140	124	16	7:10	120	141	21	8:10	141	133	8
16	7:8	141	128	13	8:1	128	144	16	9:4	121	115	6
17	9:4	150	130	20	7:9	121	139	17	8:9	142	135	7
18	7:5	134	116	18	7:1	125	137	12	8:6	133	127	6
19	6:11	134	111	23	6:8	111	125	14	8:7	132	122	10
20	8:9	147	122	25	9:5	139	158	19	7:9	130	124	6
21	8:5	148	120	28	6:9	112	121	9	8:9	141	132	9
22	7:10	144	116	28	8:8	130	147	17	8:6	137	126	11
23	8:7	150	128	22	9:	130	151	21	8:11	142	132	10
24	9:	149	124	25	8:4	121	145	24	7:3	133	121	12
25	8:9	155	128	27	7:11	120	141	21	9:3	147	135	12
	202:8	3592	3048	544	200:10	3080	3541	460	204:6	3357	3166	191
Av	8:1	143.68	121.92	21.76	8:0	123.2	141.64	18.4	8:2	134.28	126.64	7.64
*A. D.....	6.04	5.92	3.70		5.20	5.70	2.96		5.57	4.77	2.13	

* Average Deviation from the average which is shown just above in each case.

The foregoing tabulated measures were given as samples of the general run of the measures of hand and arm skill as shown by each of the three tests employed. The following tabulation gives the summary of skill tests of the entire 1125 individuals, grouped as follows:

1. The seventy-five 14-16 year old boys, tested with the shot tube.

2. Three hundred men, 40-50 years of age (over $39\frac{1}{2}$ and under $50\frac{1}{2}$ years), 100 men in each of the three handedness groups, tested with the shot tube.

3. The seventy-five 21-24 year old women, tested with the peg board.

4. Three hundred men, 50 to 60 years of age (over $49\frac{1}{2}$ and under $60\frac{1}{2}$ years), 100 men in each of the three handedness groups, tested with the peg board.

5. The seventy-five 7-9 year old girls, tested for the tapping rate.

6. Three hundred women, 30-40 years of age, (over $29\frac{1}{2}$ and under $40\frac{1}{2}$ years), 100 women in each of the three handedness groups, tested for the tapping rate.

Beginning at the left of the page the first column gives the age range of the specified group of pure right handers, the second column gives the average age of the group (14:11 means 14 years and 11 months); the third column gives the average skill shown by the right hand; the fourth, the average skill shown by the left hand; and the fifth, the average range of skill, or the difference between the average records of right and left hands. The next four columns give similar facts for the pure left handers, and the last four columns similar facts for the transfers. The average deviation (A. D.) from the average is given just below the average in each case to show the deviation from the central tendency.

SUMMARY OF SKILL TESTS

Shot Tube

(The records show the number of seconds required to load 25 shot.)

Age Group.	Pure Right Handers.				Pure Left Handers.				Transfers.		
	Av. Age.	Right Hand.	Left Hand.	Range.	Av. Age.	Right Hand.	Left Hand.	Range.	Av. Age.	Major Hand.	Minor Hand.
14 to 16 years.....	14:11	39.24	45.07	5.83	15:	45.14	40.25	4.89	15:1	41.98	43.69
*A. D.		3.65	3.33	.88		3.79	3.19	1.21		3.79	3.64
40 to 50 years.....	44:4	37.36	42.07	4.73	46:3	41.84	37.50	4.34	45:8	39.21	41.53
*A. D.		2.99	2.66	1.14		3.04	2.79	.79		2.07	2.05
											1.70
											.81
											2.32
											.68

Peg Board

(The records show the number of pegs placed in 30 seconds.)

21 to 24 years.....	22:5	35.84	30.64	5.2	22:9	31.64	36.04	4.4	22:7	33.04	31.60
*A. D.		2.74	2.85	1.52		2.43	2.60	1.07		1.32	1.84
50 to 60 years.....	56:1	30.08	26.12	3.96	54:2	26.84	30.96	4.12	55:3	28.92	26.64
*A. D.		2.25	2.06	.70		2.60	2.05	.65		2.18	2.45
											.87
											1.44
											.86
											2.28
											.87

Tapping Rate

(The records indicate the number of taps in 30 seconds.)

7 to 9 years.....	8:1	143.68	121.92	21.76	8:	133.2	141.64	18.4	8:1	134.28	126.64
*A. D.		6.04	5.92	3.70		5.20	5.70	2.96		5.57	4.77
30 to 40 years.....	35:4	204.4	181.12	22.92	34:2	182.24	201.	18.76	37:2	195.04	186.48
*A. D.		6.84	7.09	2.41		6.57	8.56	.397		6.92	4.52
											7.64
											2.13
											8.56
											3.75

* The Average Deviation is computed on the average which is given just above in each case.

INTERPRETATION OF DATA.

1. Shot Tube Data.

The summary of the shot tube tests with seventy-five 14-16 year old boys shows (1) that 25 pure right handed boys, averaging 14 years and 11 months of age, require on the average 39.24 seconds to load 25 shot with the right hand, and 45.07 seconds for the left hand; (2) that 25 pure left handed boys, averaging 15 years of age, require on the average 45.14 seconds to load 25 shot with the right hand, and 40.25 seconds for the left hand; and (3) that 25 transferred boys, averaging 15 years and 1 month of age, require on the average 41.98 seconds to load the 25 shot with the major hand, and 43.69 seconds for the minor hand. These facts mean that the pure left handed boy is about as skillful with his left hand as the pure right handed boy is with his right hand, but that the transferred boy falls below the pure right and the pure left handed boy in major hand skill. The skill ranges show that the pure right handed boy has a right hand skill ranging 5.83 seconds better than that of the left hand; that the pure left handed boy has a left hand skill ranging 4.89 seconds better than that of the right hand, and that the transferred boy has a major hand skill ranging only 1.7 better than that of the minor hand. The shot tube tests with the three hundred 50-60 years old men show (1) that 100 pure right handed men, averaging 44 years and 4 months of age, require on the average 37.36 seconds to load 25 shot with the right hand, and 42.07 second for the left hand; (2) that 100 pure left handed men, averaging 46 years and 3 months of age, require on the average 41.84 seconds to load 25 shot with the right hand, and 37.5 seconds for the left hand; (3) that 100 transferred men, averaging 45 years and 8 months of age, require on the average 39.21 second to load 25 shot with the major hand and 41.53 seconds for the minor hand. These facts mean that the pure right handed man and the pure left handed man are about equal in hand skill, but that the transferred man falls below the pure right hander and the pure left hander in extreme skill. The skill ranges show that the pure right

handed man has a right hand skill ranging 4.73 seconds better than that of the left hand; that the pure left handed man has a left hand skill ranging 4.34 seconds better than that of the right hand, and that the transferred man has a major hand skill ranging only 2.32 seconds better than that of the minor hand. According to the shot tube test, therefore, it appears that both the pure right and the pure left hander have a major hand of comparatively high grade skill and a minor hand of comparatively low grade skill, while the transfer has two hands of about equal and ordinary skill.

It may be noted in passing that the pure left hander in each group falls below the pure right hander in skill range, veering toward the transfer type of skill. This may be explained by the fact that nearly all born left handers meet more or less purposive interference tending to transfer them to the right hand in accordance with tradition. The pure left handers of this study are pure only in the sense that they are still using the hand which they were born to use; but an examination of the tabulated data readily discloses the fact that many of them show taints of transfer by their range of hand skill, and that the pure left hand group as a whole is shown by the skill range to possess the transfer taint. [Biervliet evidently saw this fact for he says, "Am-bidexters thus appear to be a variety of left men with greater symmetry."]

2. Peg Board Data.

The summary of the peg board tests with the seventy-five 21-24 year old women shows (1) that the 25 pure right handed women place on the average 35.84 pegs in 30 seconds with the right hand, and 30.64 with the left; that is, they reveal close to 36 degree (35.84 degree) skill with the right hand and close to 31 degrees (30.64 degree) skill with the left; (2) that the 25 pure left handed women place on the average 31.64 pegs in 30 seconds with the right hand, and 36.04 pegs with the left hand; that is, they reveal close to 32 degree skill with the right hand and 36 degree skill with the left hand; (3) that the 25 transferred women place on the

average 33.04 pegs with the major hand, and 31.60 pegs with the minor hand; that is, they show 33 degree skill with the major hand, and 32 degree skill with the minor hand. These facts undoubtedly mean what was found true in the shot tube tests; namely, that the pure right hander and the pure left hander are about equal in major and minor hand skill, respectively, but that the transfer falls below both the pure right and the pure left hander in extreme skill. It is noteworthy, too, that in spite of the fact that the pure left handers show a little higher average skill in either arm than is shown by the pure right handers, yet we find a lower range of skill and a deviation toward the transfer type. The peg board tests with the three hundred 50-60 year old men show (1) that the pure right handers reveal 30 degree skill with the right hand, and 26 degree skill with the left; (2) that the pure left handers reveal close to 27 degree skill with the right hand, and nearly 31 degree skill with the left; and (3) that the transfers reveal 29 degree skill with the major hand, and 27 degree skill with the minor hand. Here, too, the skill ranges show that both the pure right and the pure left hander reveal a major hand of comparatively extreme skill and a minor hand of comparatively low grade skill, while the transfer reveals two arms of about equal and ordinary skill. The transfer begins to appear to approximate ambidexterity without extreme skill. Once more it is noteworthy in passing that the pure left hander, in spite of the fact that his skill in placing pegs is a shade superior to that of the pure right hander, shows the same lower skill range and deviation toward the transfer. This is undoubtedly further evidence of transfer taint.

3. Tapping Rate Data.

The summary of the tapping rate tests with seventy-five 7-9 year old girls shows (1) that the 25 pure right handed girls reveal 143.68 degree skill with the right arm, and 121.92 degree skill with the left arm; (2) that the 25 pure left handed girls reveal 123.2 degree skill with the right arm, and 141.64 degree skill with the left arm; (3) that the transfers reveal 154.28 degree skill with the major

arm, and 126.64 degree skill with the minor arm. The tapping rate tests with the three hundred 30-40 year old women show (1) 204.4 degree skill in the right arm and 181.12 degree skill in the left arm of pure right handers, (2) 182.24 degree skill in the right arm and 201 degree skill in the left arm of the pure left hander; and (3) 195.04 degree skill in the major arm and 186.48 degree skill in the minor arm of the transfers. The ranges of skill for the two arms reveal once more that the pure right and the pure left handers show comparatively high grade skill in the major arm and comparatively low grade skill in the minor arm, while the transfer again appears to approximate ambidexterity, without extreme skill. Taints of the traditional transfer ambition of the race are again evident in the deviation of the pure left hander toward the transfer in his range of skill.

Division of Labor in Hand Work.

The question now arises, Is the workman of today better equipped with two equal arms of ordinary skill or with one arm of high grade and another of low grade skill? It takes but a little study of the use of hands and arms in the skilled labor of the world today to convince the honest inquirer that the finest skilled labor is one handed skill. When a man works with spade or shovel or pitchfork or hoe, it ordinarily make little difference whether he puts the right or left hand forward, since the labor is what we may call rough or coarse work, dealing with relatively inexact lines, distances and quantities that are not measured by the micrometer or the milligram. The ditcher works by the rod, the shoveler by the ton or by the hour, the haymaker thinks in terms of the day or of the ton, and so on. The fact is, it may be an advantage for any of these laborers to work first right or left handed and then change. Some degree of relief or rest may come through the change without loss, and perhaps with gain, in the total results. But when the skilled surgeon removes the goiter he hardly trusts the knife in his minor hand when he works near the carotid artery or the jugular vein; the skilled watchmaker

hardly trusts the miniature screwdriver in his minor hand when he seeks to adjust the microscopic screw. and the skilled draftsman hardly takes his pencil in his minor hand when he seeks an exact termination of a fine line. The fact is, skilled labor is today essentially one hand skill, and it is becoming more and more one handed in the degree that heavy labor is given over to machinery and the human hand is reserved for the skillful management of that machinery. The finest handwork calls for one highly skilled working hand and for one or more helping or holding hands. Skilled work calls for brief periods or moments of skill, with pauses liberally interspersed for calculating and adjusting. Change of hands could hardly relieve the skillful workman, since it is not the moment of skilled effort that wearies him, but rather the responsibility of reaching fine results, moment by moment; and this could not be relieved by shifting to another hand controlled by the same brain. Then, too, extreme skill requires continual and consistent exercise, not only to acquire but to retain. Finished skill is the last to be acquired and the first to disappear. Division of labor in handwork therefore favors hand skill by limiting the range of things done by one hand; and were we born with two potentially equal arms, or even with four, it were still prudent to train each hand for its own special work. We can not agree with Ballard when he says "there can be no objection" to "a more even distribution of dexterities between the two hands," even though he makes "the important proviso that writing should always be done with the superior hand." (*Jour. of Exp. Ped.*, Vol. L, No. 4, p. 309.) It is extreme effort along with extreme guidance, extreme circumspection, that wins; and the total amount of exercise required to sustain a given grade of any given hand skill in one hand would be quite inadequate to maintain that hand skill if divided between two hands. This study shows that the pure right hander is slightly superior in hand skill to the pure left hander, tainted with ambidexterity as the left hander commonly is, and that both are

clearly superior to the transfer. *The total hand and arm exercise in any specific line of activity can not maintain in two hands and arms the same high pitch of skill that it can maintain in one; and this fact, along with the principle of natural selection may yet be made to account for the fact that the race is unidextrous and not ambidextrous. (This suggestion agrees with the theory of Dr. Felix Regnault.—*Revue Scientifique*, Paris, June 13, 1914.)

In the world of skilled labor, therefore, the transfer is at a disadvantage. He can not hope to compete with the extreme skill of either the pure right or the pure left hander; and the parent or teacher who assumes to follow tradition in transferring the born left handed child, must also assume the responsibility for crippling him in the world of skilled labor. Some ambidexters show considerable skill in some forms of labor, but this only suggests what these same individuals might have accomplished had they been permitted fully to develop their major arm potentialities.

We are then driven to believe that it is a bad tradition that shifts the born left handed child to the right hand, for at least two reasons; namely, (1) it endangers his speech, and (2) it cripples his hand and arm skill; and the fact that so many children are transferred by accident (1% of both right handers and left handers), many of these in turn being unknown until revealed by arm measures, gives sufficient ground for the conviction that every child should be measured early in life to give assurance of his birthright of hands. Such a routine procedure would make it possible to preclude all hand transference excepting such as may be unavoidably due to incapacitation of hand or arm or tongue (aphasia), through injury or disease.

* A little study of the data will show that the average skill of the two hands and arms of the transfer is but little less than the average skill of the two hands and arms of the pure right or of the pure left hander, but his division of labor between the two hands is undoubtedly responsible for the fact that he lacks extreme skill.

CONCLUSIONS.

Based on the data of this study, we may draw the following conclusions:

1. The human being is born with a major and a minor hand and arm. 96% of the race are born right handed, and 4% left handed.

2. Born handedness is revealed by the bones of the arm—the major arm having the more massive bone equipment—and this evidence is present at birth.

3. The most convenient measures for determining born handedness are—

1. The length of the ulna plus (ulna plus hand to middle - knuckle of little finger).
2. The circumference of the palm.
3. The circumference of the wrist.
4. The length of the humerus.

4. Adopted handedness is revealed by the muscle swells of the arm—the adopted, or preferred, arm having the higher per cent of swell.

5. The most convenient measures for determining adopted handedness are—

1. The circumference of the relaxed forearm taken within the zone of maximum swell.
2. The circumference of the contracted forearm taken within the zone of maximum swell.
3. The circumference of the relaxed arm taken within the zone of maximum swell of the biceps.
4. The circumference of the contracted arm taken within the zone of maximum swell of the biceps.

(The difference between the relaxed and contracted measures of any muscle, divided by the relaxed measure, gives the percentage of swell.)

6. Transferred handedness may be found by comparing the bone measures of the arm and hand with the muscle swell measures of the arm. A born right hander who

has adopted the left hand, or a born left hander who has adopted the right hand, is transferred.

7. Three-fourths of all born left handers are transferred to the right hand, either by accident or by purposive interference. Approximately 1% of either born right or born left handers are transferred by accident. One individual out of about 25 adopts the potentiality minor arm.

8. Physiological disaster in the form of stammering is imminent in hand transference. One-third of all left-to-right transfers and one-sixth of all right-to-left transfers are afflicted with stammering, as against approximately 1% of all pure left handers (tainted or untainted with transfer tradition) and less than 1% of all pure right handers.

9. Stammering is intimately associated with writing with the potentially minor hand, and the traditional transfer of the left handed child to his right hand in writing is to be condemned as unwarranted and dangerous interference.

10. The pure right hander reveals about the same degree of hand skill as the pure left hander who has not been interfered with in the free use of his left hand; but the transfer lacks the extreme skill of the pure right and of the pure left hander, and he can not hope to compete successfully with the pure handed in the skilled labor of the world. The transfer has two ordinary arms rather than one skilled and one helping arm.

11. The ambidexter is a transfer, or near transfer, either from left to right or from right to left. The more marked the general ambidexterity, the nearer the individual is to the neutral line of hand-skill variation, and the lower the range of skill.

12. The evidence of born handedness is present at birth; hence it is possible to measure the child for born handedness early in life and so prevent any hand transference except such as may be necessitated by injury or disease.

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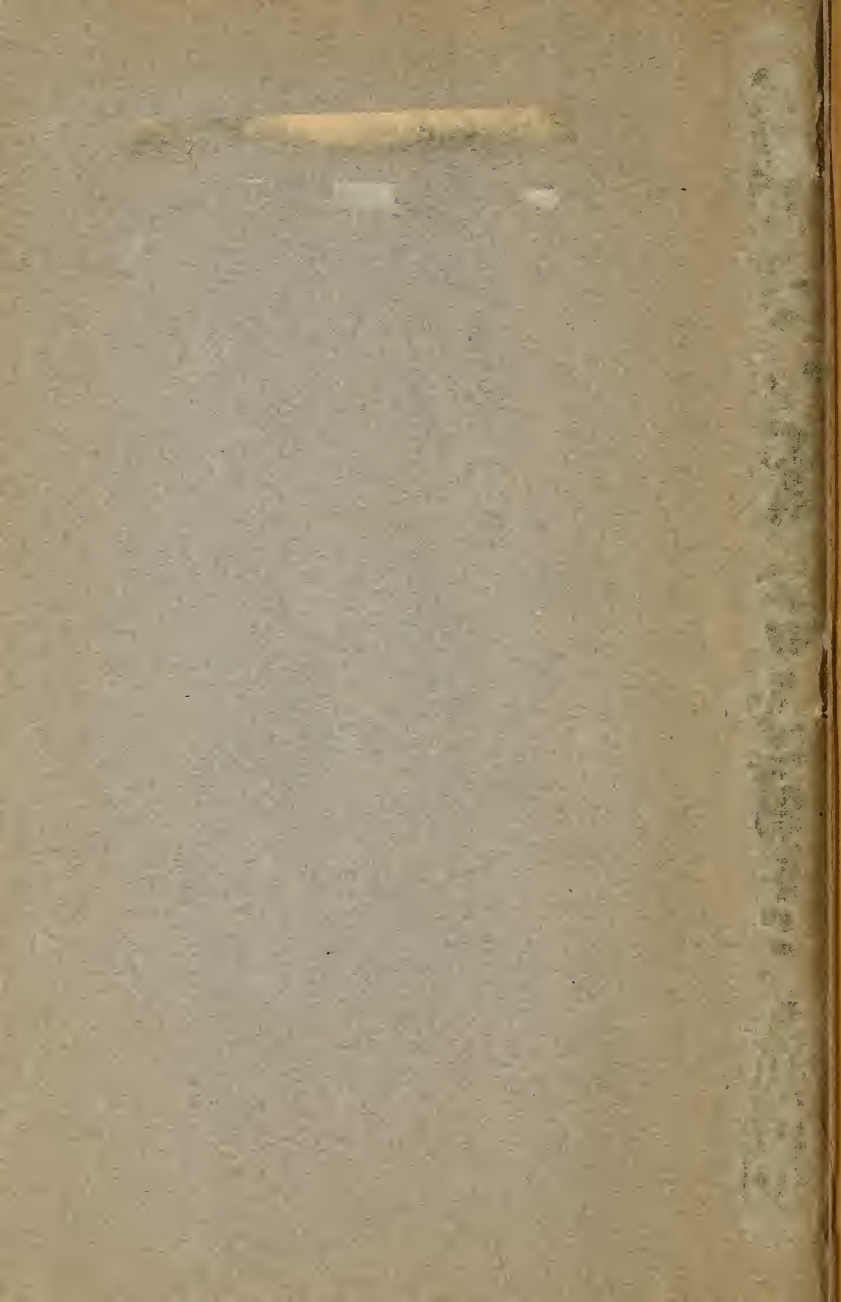
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